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## WITH ABSTRACT OF THE LITERATURE

Editor, United States
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**The Occurrence of Boils among Men Working in Coal Mines**

**Control of the Silicosis Hazard in the Hard Rock Industries. III. Design and Operation of a Dust Control System for Use with Pneumatic Rock Drills on Open Excavation**

**Cutaneous Papillomas among Patent Fuel Workers in Relation to Malignant Disease**

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# THE JOURNAL OF INDUSTRIAL HYGIENE

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## THE OCCURRENCE OF BOILS AMONG MEN WORKING IN COAL MINES*


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*H. M. Medical Inspector of Mines*


OCCASIONALLY men employed in coal mines, often when working in certain stalls or places in the mines, develop boils in such numbers as to suggest a mild epidemic. The observation of this fact led to inquiries which had for their object the determination of a specific cause.

Many factors were blamed by the workmen, such as the hardness of the drinking water, the type of coal, inadequate ventilation, and water either which dropped from the roof or in which men might stand while working. In order to decide which, if any, of these causes was actually responsible, information was obtained from twenty-nine coal mines, and about 200 men were medically examined. The investigation proceeded along two main lines: (1) the examination of the men; and (2) the examination of conditions prevailing at various mines.


*Received for publication March 25, 1932.


### MEDICAL EXAMINATION OF MEN

The examination of the men did not reveal any one definite factor. It was noticed, however, that many of the men had recently resumed work after having been idle for a year or more; during this period, being out of work, they were probably undernourished. On the other hand, boils were found among men who were obviously hale and hearty.

In many cases a crop of boils could be traced to an initial lesion. For example, 10 cases started over the knee, 8 of which could be passed as miners' beat knee. In other cases the original focus was: back (9), elbow and forearm (9), lower third of leg (7), fingers (5), wrists (5), buttock (3), face (4), axilla (2), shoulder blade (1), neck (1), ankle (1), toe (1), abdomen (1), and thigh (4).

Most men working at a mine wear belts; and none wear collars. Also, where a group of men work together it is possible for one to infect another;

in some cases infection could be traced to other people living in the same house.

### Examination of Mining Conditions

In investigating the conditions in the mines, many points were taken into account; for instance: depth (shaft and workings where a marked difference existed), temperature readings as given by the ordinary wet and dry bulb thermometer, type of coal, state of ventilation, and the quality of drinking water. The depths of the mines visited ranged from 300 to over 1,000 yards, and the distance inby to the working places in some cases was as great as $2\frac{1}{2}$ miles.

With regard to temperature, the occurrence of boils was most noticeable in mines where the wet bulb thermometer registered 75°F. or over. It was also observed that boils occurred more often on men who sweat profusely and whose bodies consequently were covered with a fine film of coal dust. The highest temperature met with at the coal face was 93°F. dry bulb and 85°F. wet bulb; the lowest was 53°F. dry and wet bulb. In mines where the wet bulb temperature was about 75°F. or over, the men worked partially stripped, *i.e.*, in shorts and boots.

Ventilation on the whole was good. If it were noticeably otherwise, a temporary cause, such as the fall of the roof in an airway, was the explanation. Several Petri dishes containing a culture medium were exposed in the intake and return airways and at the working face in order to test the bacteriologic purity of mine air, the exposure in some cases being for from fifteen to twenty minutes; in no case was any pathologic micro-organism found.

Many types of coal were met with, but there was no reason to think that the composition of the coal had any influence, apart from the fact that some seams were hotter than others and some coals generate a very fine dust which is more difficult to remove.

With regard to water underground, irritation and smarting of the skin, which are especially severe when the miner is in bed, have been caused by droppings from the roof. A sample of such water contained 186.5 parts of sodium chloride per 100,000. At one colliery a supply of vaseline is kept underground for the men to rub into their skin after working. It is well known that prepatellar cellulitis (miners' beat knee) has been caused by the soaking of the skin where men have worked in wet places, as the resistance of the skin is lowered and the entry of staphylosocci facilitated.

The effect of drinking hard water is not easy to determine. The water drunk by miners at the colliery where the greatest number of cases occurred was found to have 16° of hardness, but a neighboring mine with a similar water supply had very few cases. A mine which had never had many cases, and at which there were none when it was visited, had drinking water of 40° hardness. It was also noticed that at some mines boils occur only in certain stalls, although the drinking water is the same for all. What is of far more importance is the fact that in hot mines many men drink large quantities of water and thus lower the percentage of chloride in the blood fluid.

It is an interesting fact that no

mines having pithead baths (with one exception, where boils were very few) were reported as having cases of boils.

## Conclusions

The conclusions arrived at were that as far as mines are concerned, boils do not present a serious problem except in a few isolated cases; and that the main factor in the causation of boils underground (apart from the predisposition to them of the individual, *e.g.*, malnutrition and seborrhea) is a high wet bulb temperature (75° and over) which at one and the same time provides suitable conditions (warmth and moisture) for the vitality of the organism and opens the sweat glands and hair follicles, thus facilitating the entry of the staphylococcus.

## Prevention

At a mine where boils occur, every effort should be made to improve the ventilation, lower the temperature, and minimize wetness. Workmen should apply an antiseptic, such as tincture of iodine, to the smallest scratch, cut, or boil, as soon as possible, and should avoid touching the site with the fingers. If large quantities of water are drunk, a small amount of salt (about 10 grains to the gallon) should be added; full use of pithead baths should be made whenever they are available.

Powdered oatmeal in the bath water not only may serve as a preventive but may help to cure. This is used a great deal in India for prickly heat—a condition which occurs mostly in the rainy season. During this season people suffer from boils, usually a large number of small ones. These multiple boils often mean that a "prickly heat" rash has become septic —*i.e.*, has become infected by the staphylococcus. Horses suffer from a type of ulcer, also during the rains. The Indians call it barsati or burrsati because it occurs only in the monsoon (barsat). If a horse gets a barsati sore, he will have an annual recurrence and will be free when the rains stop and the atmosphere becomes cooler and drier. In the hot weather (up to 115°F.) the skin is dry; in the rains the temperature is between 80° and 90°F. and the skin is damp, if not actually streaming.

## Summary

Twenty-nine mines were inspected and 200 miners were medically examined to determine the causation of occasional outbreaks of boils.

Evidence pointed to a high wet bulb temperature (75° and over) as being the main causative factor, by inducing free sweating and thus facilitating staphylococcic infection of the skin.

The outbreaks seldom present a serious problem.

# CONTROL OF THE SILICOSIS HAZARD IN THE HARD ROCK INDUSTRIES. III. DESIGN AND OPERATION OF A DUST CONTROL SYSTEM FOR USE WITH PNEUMATIC ROCK DRILLS ON OPEN EXCAVATION*

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## INTRODUCTION

THE existence of a silicosis hazard associated with dry drilling of silica bearing rock in open excavation was demonstrated by Smith[1] in her study of 208 drill runners, blasters, and excavators in New York City. Following the report of this survey, a committee was appointed by the New York State Department of Labor to study means for control of the dust generated by pneumatic rock drills, and under the auspices of this committee an investigation was made of the dust collecting efficiency of the Kelley dust trap. The results of this work[2] demonstrated that the trap is capable of reducing the dustiness at the breathing zone of the drill runner to a concentration within the limit suggested for hygienic safety.

This first investigation was admittedly experimental and it remained to determine the practicability of the trap under conditions of field practice. It was necessary further to develop a suitable method of removing the collected dust from the exhaust air previous to its discharge from the exhaust system, in order that no dust hazard would be produced at the street level or other discharge area.

A large scale installation was made by the Metropolitan Life Insurance Company on the excavation job for its new building in New York City, which provided an opportunity for further study under conditions of actual plant operation. The installation was made according to plans prepared by one of us (G. S. K.),

* A co-operative study from the New York State Department of Labor, the Metropolitan Life Insurance Company, and the Department of Industrial Hygiene, Harvard School of Public Health.

Received for publication March 18, 1932.

[1] Silicosis among Rock Drillers, Blasters, and Excavators in New York City, Based on a Study of 208 Examinations. THIS JOUR., 1929, *11*, 37.

[2] Hatch, T., Kelley, G. S., and Fehnel, J. W.: Control of the Silicosis Hazard in the Hard Rock Industries. II. An Investigation of the Kelley Dust Trap for Use with Pneumatic Rock Drills of the "Jackhamer" Type. THIS JOUR., 1932, *14*, 69.

under whose charge the equipment was operated. A description of the plant, together with some of its features of operation, is given in the present paper.

## Description of Plant

### *Exhaust Piping*

In open excavation for building foundations, the rock is commonly removed by the so-called bench system. Each bench, approximately 12 feet in depth, is started at the center of the area and carried out to the building line. A new bench is started, however, as soon as the overlying rock is removed from the central area. Thus operations are carried on simultaneously on several bench levels, and consequently rock drills may be in use over the entire area, along the building line as well as in general field drilling. In order to care for such scattered operations, therefore, the exhaust piping must be carried around the excavation and must be provided with a number of flexible branches connecting with the exhaust hoods.

The exhaust piping employed on the excavation for the Metropolitan Life Insurance Company building is shown diagrammatically in Figure 1. It consisted of a 10-inch steel main which was carried around the lot at the building line, and just below the street level, forming a closed circuit approximately 800 feet in length. Fourteen 6-inch branch inlets were connected along the exhaust main, as indicated in Figure 1; in operation seven or eight of these were employed at a time, connections being made to exhaust manifolds to which, in turn, the traps were connected, each manifold having connections for ten drills. Six-inch flexible hose was used for the branch connections, and 2-inch hose between the traps and manifolds. In both cases the length of hose was varied to meet existing conditions; for the 2-inch hose, the maximum was 100 feet.

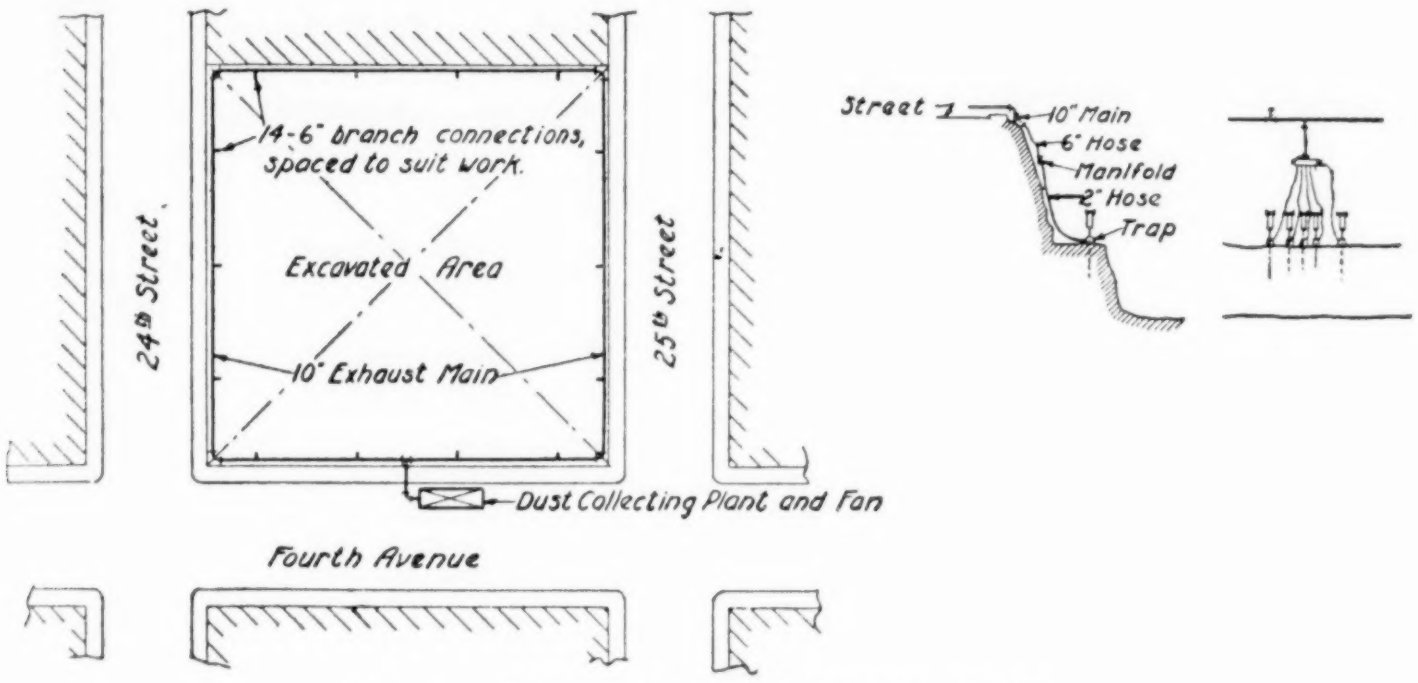


FIG. 1.—General layout of exhaust piping

Pipe diameters were selected to produce air velocities high enough to convey the collected material. As a precautionary measure, however, clean-out plates were installed at bends and other points where dust might settle out.

The exhaust system was designed for a capacity of forty drills and provided with Kelley traps of the general type shown in our previous paper.

*Dust Collecting Plant*

A number of methods of dust collection have been developed, differing in principle of operation and in efficiency. The design of a plant to meet the conditions of a particular problem must be based in the main upon three factors: (1) efficiency of collection required; (2) nature of material to be handled, such as particle size; and (3) amount of dust to be collected and the loading per unit volume of air.

*Required Efficiency of Collection.*—On open excavation work where the disposal plant may be located in an open area, the efficiency of dust removal from the exhaust air must be high enough simply to prevent the production of a dust hazard at the street level or in the general discharge area. Owing to the dispersion and dilution by wind currents, the dust concentration in the air discharged from the collector may exceed the limit set for hygienic safety without adding sensibly to the general atmospheric pollution. In this connection, however, it should be emphasized that care must be exercised in choosing the best location for the disposal plant, and that the efficiency of dust collection must be based upon local conditions, such as closeness of neighboring buildings and nature of wind currents. On extensive operations it may be desirable to employ a portable collector that can be moved about as the work progresses; under such conditions a higher efficiency of collection will be required than in the case of discharging into an open area above the street level.

In the present installation, the disposal plant was located about midway on the Fourth Avenue side of the lot. The point of discharge was approximately 8 feet above the sidewalk and more than 60 feet from the nearest building. The open area was greater than 300 feet square and was bounded by streets on three sides.

*Nature of Collected Material.*—The dust produced by rock drills varies from particles one-fourth inch or more in diameter down to submicroscopic sizes. In the present installation, the collected dust gave the approximate screen analysis shown in Table 1. Of the material passing the 325-mesh screen, a considerable portion was found to be less than 10 microns in size. The collection of such nonuniform material involves at least two steps: the removal of coarse particles (above 40 microns in size) by preliminary sedimentation, and the separation of the fine material by

TABLE 1.—APPROXIMATE SCREEN ANALYSIS OF ROCK DUST COLLECTED FROM PNEUMATIC ROCK DRILLS

| MESH SIZE | PERCENTAGE BY WEIGHT PASSING SCREEN |
|---|---|
| 20 | 97.3 |
| 40 | 91.3 |
| 60 | 77.6 |
| 80 | 74.5 |
| 100 | 63.8 |
| 120 | 62.5 |
| 150 | 57.8 |
| 200 | 47.3 |
| 325 | 36.2 |

filtration. It is essential that the efficiency of collection in the preliminary stage be made as high as possible in order that the load on the filters may remain at a low value.

*Amount of Dust Collected.*—In building excavation, practice holes varying in diameter from 2 to $1\frac{3}{8}$ inches are ordinarily drilled at intervals of 2 feet to a depth of 12 feet. The total volume of each hole is therefore 0.1895 cubic foot, and the average volume per foot drilled is 0.0158 cubic foot. Assuming an average

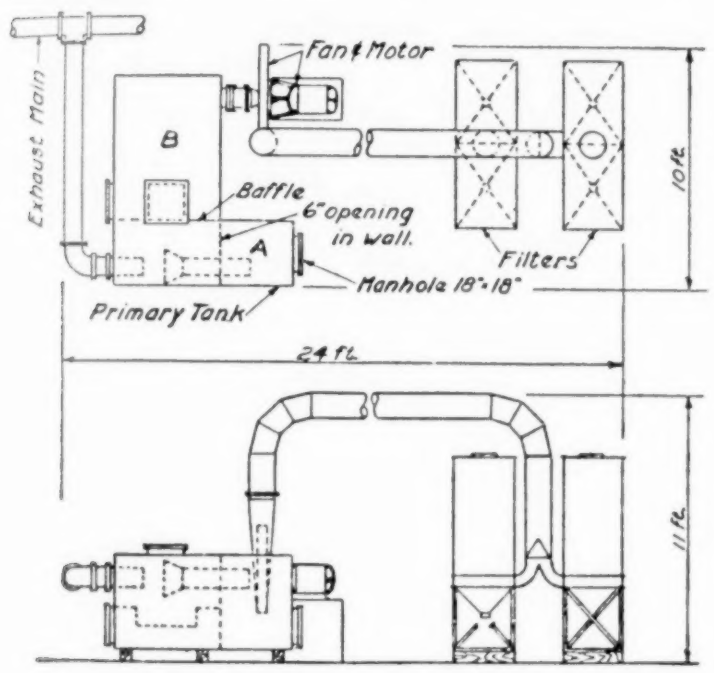


FIG. 2.—Layout of dust collecting plant and exhaust fan, with approximate over-all dimensions.

footage of 100 feet a day per drill, a total volume of 1.58 cubic feet of stone will be removed; and on the basis of 50 per cent. voids, the dust generated will occupy a volume of 3.16 cubic feet. For stone weighing 150 pounds a cubic foot, this amounts to 237 pounds, and assuming 100 per cent. collection, the dust loading in the exhaust system will be 0.0082 pounds per cubic foot of air (57.4 grains per cubic foot) and the density of the mixture of dust and air 0.083 pounds per cubic foot (compared with 0.075 for clean air at 65°F.).

*Dust Collecting Equipment.*—To meet the conditions outlined above, the dust collecting equipment employed consisted of two stages of separation: a preliminary sedimentation chamber, and cloth screen filters with the exhaust fan located between them. The plant layout is shown diagrammatically in Figure 2.

The preliminary tank included two stages, the first of the inertial type and the second employing plain sedimentation. Owing to the high velocity of discharge of the incoming dust laden air, a considerable portion of the dust was projected through the bell shaped entrance into compartment A where it was removed from the small amount of air that entered with it, the latter escaping into the second compartment through a suitable opening. Compartment B, provided with a baffle plate as shown, served as a plain settlement chamber for the further removal of fairly large material. The efficiency of the second compartment was found to be materially increased when it was filled with water to a depth of approximately 6 inches.

The secondary stage of cleaning was effected by means of cloth screen filters. Two units, each having a net filtering area of approximately 500 square feet, were connected in parallel to the discharge line from the fan. The ratio of air flow to filter area was approximately 3 to 1. Both units were provided with manually operated shaking devices and storage hoppers for the collected dust. The filtered air was discharged through openings 12 inches in diameter in the top of each filter housing. Frequency of cleaning was determined by the pressure drop

across the filter, which was measured by a water manometer provided for the purpose.

*Exhaust Fan.*—To meet the requirements of air flow and resistance imposed by the installation, a single-stage centrifugal compressor was supplied, which was connected directly to a 27-horse-power motor. The rate of air flow through the system was measured by an electric flowmeter and controlled by varying the motor speed.

## Operating Characteristics

### *Pressure Losses through System*

The total pressure drop across the exhaust system and dust collecting plant was found to be 24 inches, water gauge, or 1.78 inches of mercury. Manometer readings showed that over half the total pressure drop occurred in 100 feet of 2-inch flexible hose. This could be reduced materially by increasing the diameter of the hose and confining its use to shorter lengths. The small diameter was chosen, however, for convenience in handling—a consideration that probably justifies its use.

### *Dust Collection*

The efficiency of dust collection in a plant of this type, particularly the individual efficiencies of the various parts of the separator, is of special interest from the standpoint of design and operation. From the hygienic point of view, however, efficiency of collection is of less interest than the actual dust concentration in the air discharged by the collector.

Determinations of efficiency were made with from twenty-five to thirty drills in operation. From the results shown in Table 2, it will be observed that about 75 per cent. of the collected material was removed in the preliminary tank and that an over-all efficiency of 99.7 per cent. was obtained. The uneven collection shown by the two filter units was caused by the fact that the connecting pipe made a 90° bend just above the filters, which had a tendency to throw the dust to the outside of the elbow and therefore into the filter unit connected on this side.

TABLE 2.—TYPICAL DATA ON DUST COLLECTION DURING EIGHT-HOUR RUN WITH TWENTY-FIVE TO THIRTY DRILLS IN OPERATION

| REMOVED IN | | CUBIC FEET | PERCENTAGE OF TOTAL |
|---|---|---|---|
| Compartment | A | 31.50 | 53.3 |
| | B | 12.50 | 21.1 |
| Filter | No. 1 | 6.75 | 11.4 |
| | No. 2 | 8.25 | 13.9 |
| Discharged (approximately) | | 0.20 | 0.3 |
| Total | | 59.20 | 100.0 |
| Over-all percentage collected | | ..... | 99.7 |

Approximate dust concentrations in the air discharged from the filters were determined by the impinger method and found to be satisfactory.[3]

Screen analyses of samples taken from the two compartments in the preliminary tank, of samples of the dust entering the filters, and of a com-

[3] Dust determinations were made by J. W. Fehnel, Chief Chemist, Laboratory of Industrial Hygiene, Metropolitan Life Insurance Company, New York City.

posite sample from the two filter units are given in Table 3. A continuous decrease in size will be observed except in the case of the composite sample from the filters. The increase in size observed in this case over that found for the incoming dust is due to the fact that some of the very small particles discharged from the preliminary tank also escaped through the filters.

TABLE 3.—SCREEN ANALYSES OF SAMPLES OF DUST TAKEN FROM VARIOUS STAGES OF DUST DISPOSAL PLANT

| MESH SIZE | PERCENTAGE PASSING SCREEN | | | |
|---|---|---|---|---|
| | Compartment A | Compartment B | Discharge from Preliminary Tank | Composite from Filters |
| 20 | 96.4 | 96.6 | .... | .... |
| 40 | 86.4 | 93.5 | .... | .... |
| 60 | 62.5 | 88.4 | .... | .... |
| 80 | 57.8 | 85.7 | .... | .... |
| 100 | 39.7 | 80.75 | .... | .... |
| 120 | 38.2 | 78.5 | .... | .... |
| 150 | 31.7 | 72.8 | .... | .... |
| 200 | 16.4 | 64.2 | 97.5 | 96.5 |
| 325 | 4.7 | 46.1 | 93.5 | 82.5 |
| 400 | .... | 41.6 | 91.0 | 80.0 |

The amount of material collected during an eight-hour working day varied with the number of drills in operation. During one day, when more than sixty drills were in use, a total of 104 cubic feet, or approximately 4 tons, of material was removed from the collecting plant. During the period of operation from June 1 to November 15, more than 350 tons, or an average of approximately 3 tons daily, were collected. The collection of such large quantities of material requires storage space adequate for at least four hours of operation, and facilities for convenient and safe removal of the dust must be provided. For a storage period of four hours, a primary tank similar to the one employed in the present instance should have storage capacities of 28 and 11 cubic feet in the first and second compartments respectively.

*Disposal of Collected Material.*—Dust was removed twice daily from the primary tank and once from the filters. It was placed in a metal tank and thoroughly wet down before being transferred to trucks for removal from the job. Considerable care should be exercised in the cleaning operation, in order to prevent escape of dust to the atmosphere. As a precautionary measure, the plant operator and assistants should be supplied with efficient dust masks to be worn during this work. The collected dust must be removed from the site and disposed of in a safe manner.

*Filter Operation.*—Frequency of cleaning of the filters was governed by the pressure drop across them. The resistance was read and recorded at intervals of from thirty to forty-five minutes, and the filters were cleaned when the manometer reading reached 5 inches. The frequency of cleaning varied with the number of drills in operation, ranging from a minimum of four to ten times in eight hours. In order to clean the filters it was necessary to shut down the exhaust fan; hence no dust was removed from the drills during the cleaning intervals of about five minutes. For convenient operation and continuous dust control, certain im-

provements should be made in the design of disposal plants for future installations. First, a primary tank having a higher efficiency of collection should be employed. This would reduce the load on the filters and so increase the length of runs between periods of cleaning. Second, the filters should be provided with suitable connections and gates to permit throwing one unit out of service at a time for cleaning purposes, thus eliminating the necessity for shutting down the entire plant. For the most satisfactory conditions of operation, the filters should be divided into three units and the area of filter surface increased. A ratio of 2 cubic feet per minute to each square foot of filter area is recommended instead of the ratio of 3 to 1 employed in the present plant.

*Fan Protection.*—The fan was located between the preliminary chamber and the filters, and thus received only the fine dust (less than 325 mesh). Trouble was experienced, however, with wear of fan blades, which reduced the efficiency of the system and required renewal of the fan element. To give complete protection to the fan and insure continuous maintenance of efficiency, the fan should be located on the discharge side of the filters where it will handle only relatively clean air. In this case the filters will be under negative pressure and will require a strong, air tight housing.

### *Rate of Drilling*

During vertical down drilling, without exhaust, the dust is blown out of the hole by the air stream that passes through the drill steel, and settles on the rock surface at the edge of the hole. As the mound of dust builds up, large particles fall back into the hole and are ground finer before being blown out again. This action produces a continuous cushion of dust between the bit of the drill steel and the rock, and thus retards the drilling speed. When an exhaust trap is used, however, the dust is removed as rapidly as it emerges from the hole; the cushion of dust is therefore reduced, and an increase in the rate of drilling results. This is shown by the comparative rates of drilling per hour, with and without the use of an exhaust hood, which were obtained during the investigation. The same drill was used in both tests and was provided with freshly sharpened drill steel. The tests were made within a small area so as to insure constant rock conditions. In order to eliminate the human element in the rate of drilling, a dead weight was applied continuously to the drill,[4] the drill

TABLE 4.—COMPARATIVE RATES OF DRY DRILLING WITH AND WITHOUT EXHAUST, USING TESTING TRIPOD AND WEIGHTS

Type S-49 drill and 4-wing steel used throughout.

| WEIGHT APPLIED | FEET DRILLED PER HOUR (AVERAGE OF 2 TESTS) | | PERCENTAGE INCREASE WITH EXHAUST HOOD |
|---|---|---|---|
| | Without Exhaust Hood | With Exhaust Hood | |
| *lbs.* | | | |
| 20 | 14.7 | 17.8 | 21.0 |
| 40 | 20.4 | 22.7 | 11.2 |

[4] Through the courtesy of the Ingersoll-Rand Company a special tripod testing device was provided for this purpose.

runner simply operating the machine and steadying it during its operation. Two different weights were used: 20 pounds, which represents the average force applied by the drill runner through his arms; and 40 pounds, which is approximately equivalent to the force applied when one leg is thrown over the head of the drill. The results of these tests (average of two one-hour periods in each case) show increases in the rate of drilling, when the exhaust hood is used, of 21 and 11 per cent. for the 20 and 40 pound weights respectively (see Table 4).

### *Cost of Operation*

Complete installation and operating charges against the dust control system were not available for analysis. An itemized list of representative charges has been prepared, however, and is presented in Table 5. Further experience with the operation of similar plants may change the figures in some respects although it is believed that they are fairly correct. According to this analysis the daily cost was $2.21 per drill, or $0.0221 per foot drilled (assuming a daily footage of 100 feet per drill). This amounts to 6.3 per cent. of the average drilling cost, and on the basis of cost per yard of stone removed, the figure is reduced to 1.05 per cent.

These figures make no allowance for increased rate of drilling or general improvement in working conditions, both of which would tend to decrease the net cost of operation. On the other hand, the cost per drill would be greater in the case of an installation having less capacity. Although further experience will be necessary before definite cost data can be obtained, the analysis in Table 5 indicates that the charges for protecting the workers against the dust hazard are not excessive.

TABLE 5.—COST OF OPERATING DUST CONTROL SYSTEM WITH CAPACITY OF FORTY DRILLS

| | COST PER WEEK |
|---|---|
| Cost of equipment—$6,000: | |
| Rental cost and repairs | $100.00 |
| Cost of installation—$1,000: | |
| For 6 months' use | 40.00 |
| Operation (1 plant operator and 1 fieldman to 8 drills): | |
| 6 men at $8.25 per day | 247.50 |
| Insurance at 10 per cent. of payroll | 24.75 |
| Power—625 kilowatt hours at $4\frac{3}{4}$ cents | 29.75 |
| Total | $442.00 |
| Cost per drill day | $2.21 |
| Cost per foot of drilling (assuming rate as 100 feet per day) | $0.0221 |
| Percentage added cost of dust extraction: | |
| Per foot drilled (assuming cost as 35 cents per foot) | 6.3% |
| Per yard of stone removed (assuming cost as $5.25 per yard, and 40 yards per drill day) | 1.05% |


## Summary

An investigation of the practical use of the Kelley traps for the control of dust generated by pneumatic rock drills was made on an installation used during the excavation for the new Metropolitan Life Insurance Company building in New York City.

The plant was designed for use with forty drills and the amount of dust

collected varied from 1.5 to 4 tons per day, the average being approximately 3 tons. The dust collecting plant included two stages of separation: a primary chamber for the removal of coarse material; and cloth screen filters having a net filtering area of approximately 1,000 square feet, and thus giving a rate of filtration of about 3 cubic feet per minute for each square foot of filter surface. The filters were cleaned from four to ten times daily, by manually operated shaking devices. The over-all efficiency of collection was 99.7 per cent., resulting in a dust concentration in the discharge air of from 10 to 25 million particles per cubic foot.

The use of exhaust hoods was found to increase the speed of drilling from 11 to 21 per cent., and to effect a general improvement in working conditions. The cost of operation, however, was estimated to be only $2.21 per drill day, which represents an additional cost per foot drilled of 6.3 per cent., or 1.05 per cent. of the cost per cubic yard of stone removed.

Grateful acknowledgment is made for the advice and assistance received from the New York State Department of Labor, the Metropolitan Life Insurance Company, the George J. Atwell Foundation Corporation, and Mr. I. R. Loss of the General Electric Company.

# CUTANEOUS PAPILLOMAS AMONG PATENT FUEL WORKERS IN RELATION TO MALIGNANT DISEASE*

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THE committee which was sitting in the year 1907 to discuss the question of compensation for industrial diseases was informed by Mr. J. Wignell, the organizing secretary of the Dockers' Union at Swansea, that there had been thirty-eight cases of epitheliomatous ulceration among patent fuel workers in South Wales (1).

The committee, which included the late Sir Clifford Allbutt, visited the districts around, and came to the conclusion that the lesions were specific to the trade mentioned. Its findings, briefly summarized, were as follows (1):

> Men engaged in handling the pitch or other tarry products, either in unloading pitch from vessels or railway trucks, or in the manufacture of briquettes, or in handling "coal oil" in the manufacture of grease, are liable to suffer from warty growths which ulcerate and occasionally become the seat of epitheliomatous cancer.

It found that the growths occurred on any part of the body, most commonly on the face, hands, and scrotum. These lesions were accordingly scheduled under the Workmen's Compensation Act of 1906 as "epitheliomatous ulceration, due to pitch, tar or tarry compounds."

Further information concerning the effects of pitch was obtained in the year 1911 as the result of a public inquiry made by Mr. A. H. Lush into certain proposed Home Office regulations, which required, among other things, special washing and bathing facilities for patent fuel workers in factories where pitch, other than blast furnace pitch, was used.

It was at this inquiry that evidence was forthcoming of the intense pain suffered by patent fuel workers after exposure to sun and wind at the end of the day's work. In fact, it was proved conclusively that no class of worker suffers so much from his employment as does the patent fuel worker.

The regulations proposed by the Home Office, when issued in draft form, were objected to by two Scottish firms manufacturing blast furnace pitch; they contended that blast furnace pitch was free from naphthalene and anthracene, and therefore quite different from gas works tar. They also stated that in twenty-three years no case of pitch cancer had arisen among their workmen. The actual evidence which they brought forward, however, was far from decisive. Out of thirty-two employees, only six were found who handled pitch.

In the year 1919, the trade unions concerned asked for a voluntary examination of patent fuel workers, in order that pitch lesions might be discovered early. In this way it was hoped to prevent epitheliomas from reaching an inoperable stage of growth. A conference was held between the employers and the representatives of

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the men. It was arranged that any worker over 30 years of age and with a duration of employment of over ten years could, if he wished it, be medically examined by a special doctor chosen by both parties. In South Wales, the number of men in this category constitutes about 20 per cent. of the total number of men employed, and owing to trade depression and the insidious onset of the lesions, the men were slow to avail themselves of the opportunity. In Cardiff and Swansea it was possible for any worker to consult Dr. Scholberg and Dr. Sladden, pathologists to the Cardiff and Swansea General Hospitals, respectively.

At the beginning of 1930, following recommendations from the Home Office, I was asked to undertake a periodic medical examination of the employees at a works at Cardiff. The examination was to apply only to men of 30 years of age and over who had been employed in the industry for more than ten years. The examination was to be voluntary and to take place twice a year at the works. Similar arrangements were made at Swansea and Llanelly with other medical men. I carried out the first two examinations in June and December, 1930, and in the course of them found twelve men suffering from pitch papillomas, one of which was clinically recognizable as an epithelioma. These twelve cases are included in the series of seventy-three with which this paper deals.

## General Cutaneous Changes Due To Pitch

From my own direct observation, I am led to the conclusion that all the troubles of the patent fuel worker are due to one substance alone—*viz.*, pitch. Three varieties are at present in use at the works that I visit:

1. A pitch which comes from Baltimore, Md. It leaves a yellowish coloring on the skin and causes irritation; but after washing, the men do not suffer more than when using any other kind of pitch. I have come across three or four men, however, who complain that it "punishes" them very badly, especially if they are exposed to sunlight on their way home from work.

2. Pitch from Goole, Yorkshire. The men complain that the pitch from this source causes a great deal of irritation to the skin. The chief foreman says: "The pitch from Goole leaves a yellowish coloring on the skin which is very difficult to wash off, and burns the skin more than any pitch I know of."

3. Pitch supplied by Messrs. Bird & Son, Ltd., Cardiff. This pitch is the one which is used the most frequently, as it suits the processes best. The men also prefer it to pitch from most of the other sources of supply, as it is not so irritating.

### *General Reaction of External Body Surfaces to Pitch*

When one looks around the waiting room before the evening surgery begins, it is a comparatively easy matter to distinguish a patent fuel worker from the rest of the patients. His face and neck present a very swarthy appearance, and he looks like a foreigner. The skin on close inspection presents a mottled, pitted appearance, and is of a dusky brown color. The same condition is noticeable on the hands and forearms, and its cause will now be described.

*Erythema:*

The earliest effect of the action of pitch upon the skin is erythema. This is claimed by Galloway (2). Repeated and continuous action of the irritant

eventually causes a permanent dilatation of the capillaries. In time this redness becomes dusky and congested because of stasis in the superficial vessels. In short, a chronic dermatitis develops. The surface of the inflamed area of the skin becomes dry and scaly, and studded all over it are little papules composed of thickened epithelium. These cause intense irritation and are from time to time scratched by the patient, with the result that the opened-up follicles are at once filled with pitch dust. The little keratoses thus formed vary in size from a pinhead to a split pea, and are colored brown. The skin in this state feels rough, harsh, and dry, and is covered with branny scales. Prosser White (3) describes it as shagreen; he considers that the parchment-like texture of the skin is pathognomonic of the effects upon the skin of all the carcinogenic agents in certain stages of their development.

*Folliculitis:*

This is caused by particles of pitch coming in contact with the roots of the hairs and setting up an inflammation. In the early stages, a well-defined, red areola may be seen around each hair follicle. The condition is found nearly always on the anterior surface of the thighs and on the forearms. Occasionally, however, it occurs on the face or posterior aspect of the neck.

In my experience this folliculitis *per se* has never given rise to any cancerous lesion. I think that the sebaceous gland secretions have protective qualities which are able to counteract the cancer producing properties of the pitch. In this respect it is interesting to refer again to the experiments made by Kennaway (4) on mice, which showed that where painted on the skin, pitch in benzene solution is much more toxic than when it is dissolved in a lanolin medium. It seems to me that the sebaceous gland secretions act in a similar way to the lanolin. Both, in some way or other, prevent the pitch from coming into too intimate contact with the skin tissues.

Prosser White (3, pp. 39–90), on the other hand, thinks that the abnormal activity or large size of certain glands, such as the sebaceous, may increase the predisposition to the ill effects of certain substances, such as tar and petroleum.

Kennaway (5) does not think that the abundance of sebaceous glands has anything to do with the liability of the scrotum to industrial cancer. He finds from experiments that sebaceous material is a good solvent for pitch but not superior to others in cancer production. On the other hand, he considers that the abundance of the sebaceous glands and the rugosity of the skin of the scrotum do not predispose to malignancy.

*Ocular Troubles:*

Many patent fuel workers suffer pain and discomfort in their eyes. Continuous irritation by pitch dust causes a marked injection of the conjunctival membrane. This becomes in many instances a conjunctivitis, and the workmen complain of severe burning and smarting pains in the eyes, and of inability to face light. In addition to this, there is excessive and continuous watering of the eyes.

Extreme photophobia and lacrima-

tion are, in fact, very typical of the conjunctivitis produced by pitch. When the men get home, they are unable to read the newspaper and always have to sit with their backs to the light. Some workers wear goggles, but these are mostly homemade and do not seem very effective. Pitch conjunctivitis varies in intensity and many men continue to work for a long time, enduring much suffering.

The cure of the disease is naturally abstention from work. Very rarely do pitch papillomas cause eye trouble. In one case, which will be recorded later, a corneal ulcer was produced (with associated conjunctivitis) through friction of a pedunculated papilloma against the surface of the cornea. This man developed a hypopyon and has now very little vision in the eye.

*Burning Sensations on Exposure to Wind and Sun:*

Many patent fuel workers at the end of the day's work suffer an intense burning pain over the parts of the body exposed to the sun and wind, *i.e.*, the head and neck, hands, and forearms.

Baths are provided by the employers on the premises, but they are used by only a few men, as the majority prefer to wait until they get home. They complain that the water aggravates the burning, especially as they have to walk or bicycle home afterward, exposed to sun or cold wind. The general practice among the men is to go home, bathe and have tea, and stay indoors for a while. I have been told by one man that the pain he gets is sometimes so severe that he is unable to go out at all in the evening after his tea is finished.

I have already described the three varieties of pitch used. Two varieties, the American and that obtained from Goole, Yorkshire, are far more irritant than the third. It would seem, therefore, that some pitches contain more irritating materials than others. On the other hand, it may be that the burning pain is due to a single specific irritant substance.

With regard to exposure to sunlight, I think it is quite probable that the actinic rays of the sun may cause a chemical reaction to take place in the particles of pitch deposited on the skin and in this way produce the substance responsible for the pain.

The action of wind, likewise the aggravation of the pain by the application of water, is more difficult to account for. The reaction of the skin to pitch is found in fully 80 per cent. of the patent fuel workers. As in the case of other skin affections, fair men are more susceptible than dark.

## Pitch Papillomas

### *Clinical Characteristics*

Certain special structural changes take place within the chronically inflamed area of skin, previously described as shagreen. The scaly papules or keratoses found in this condition are liable to undergo proliferative changes and to become the origin of a papillomatous growth. This, in its turn, may develop malignant characteristics and become an epithelioma. There are two types of papillomatous growth due to pitch irritation: a pedunculated wart with a small base, and a flat wart with a broad base.

*Pendulous or Pedunculated Papilloma:*

This is attached to the skin by a

slender pedicle which varies in length from about one-tenth to a quarter of an inch. These warts may be present for a very long time and give rise to no trouble so far as my observation goes. The men consider them to be of a trivial nature and call them "dry" warts. (The sessile and potentially malignant wart is described as "wet.") They are most frequently situated on the eyelids and sometimes on the nose. In a few isolated instances they may give rise to inconvenience, but for the most part they get rubbed off when the men bathe and rub themselves down with a rough towel. They sometimes leave a tiny round scar.

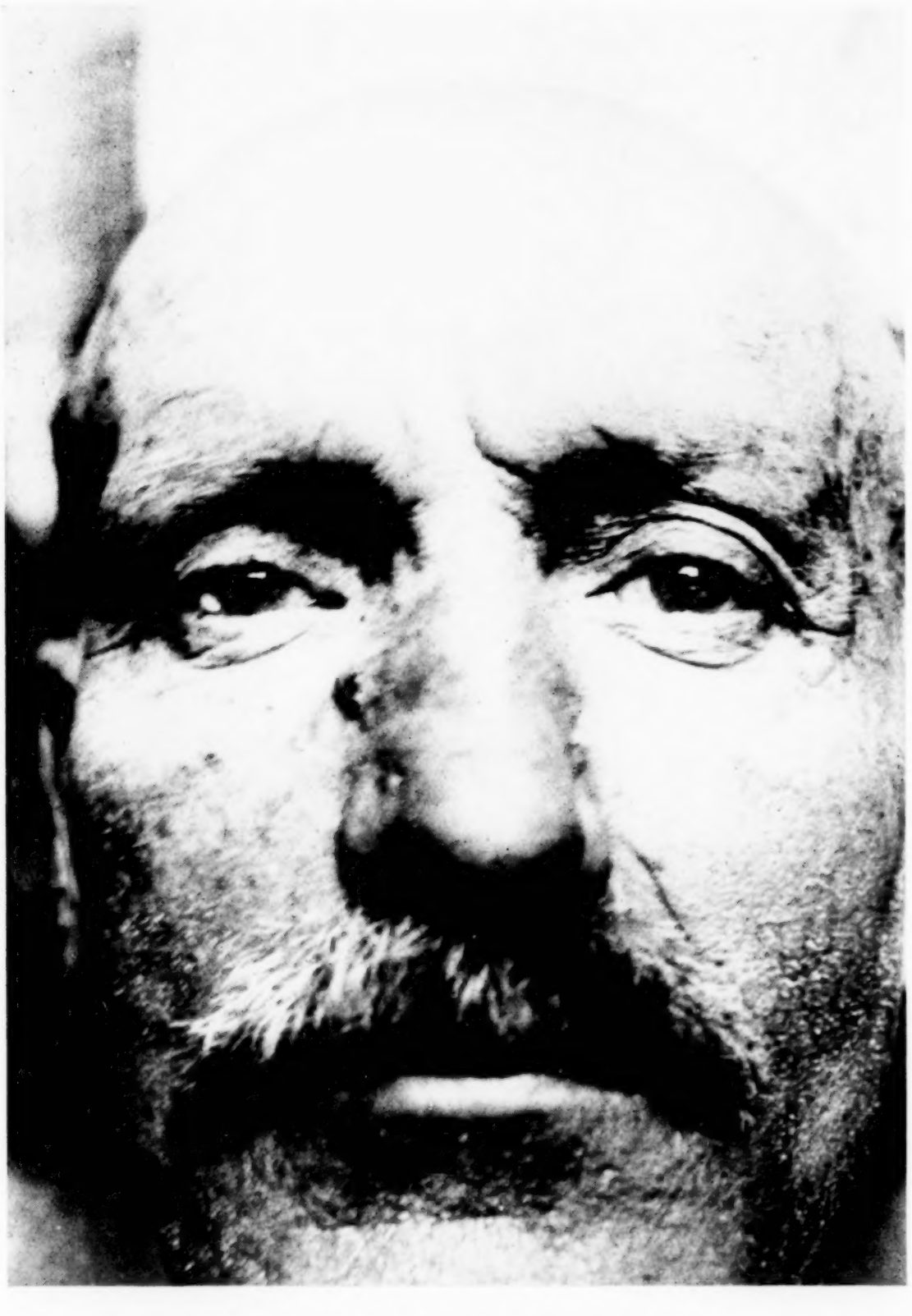

FIG. 1.—W. D., pugman, aged 50.

Showing pitch wart one-thirty-second of an inch in circumference (of three to four weeks' duration) on right side of nose. The shagreen appearance of the skin is well known, as is the watery appearance of the eyes due to blepharitis and conjunctivitis.

*Sessile or Flattened Papilloma:*

This wart is but slightly raised from the surface of the skin, and has a broad base and a smooth top. It may occur singly or in groups on the forehead, ears, nose, cheeks, and lips; it is found also on the back of the neck along the sternomastoids, and on the hands and forearms. The men are often not aware of its presence owing to its small size, which is as a rule about that of the head of a small pin. Pain generally is absent until ulceration begins.

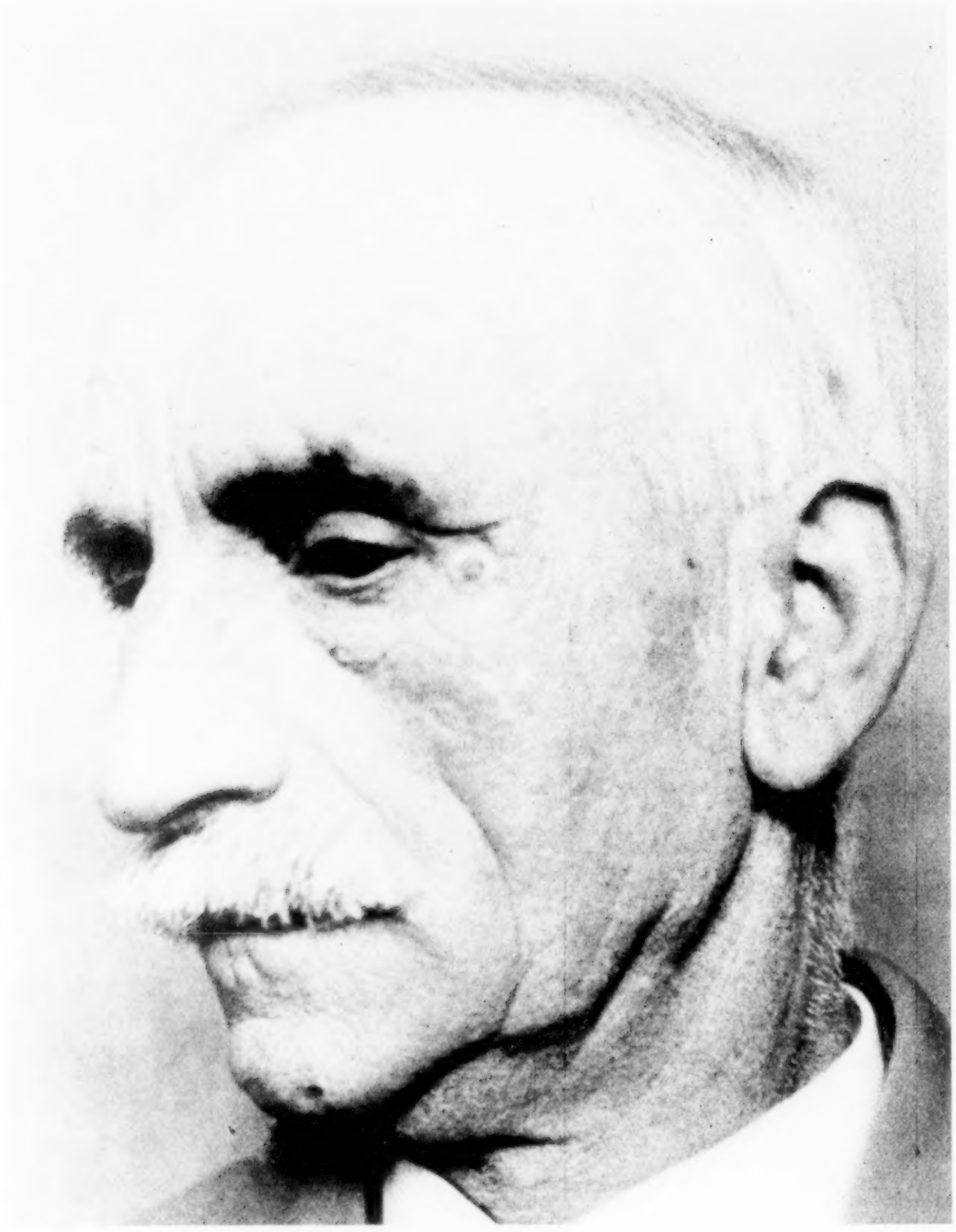

FIG. 2.—W. M., fuel piler, aged 58.

Showing a typical sessile pitch papilloma of ten weeks' duration. The central keratinoid punctum is clearly shown.

The type of papilloma which requires careful attention is the flat papilloma which is about one-fifth to one-quarter of an inch in diameter. This is the type of wart which may increase

rapidly in size, and which on cauterization will recur, and, if left unexcised, may become epitheliomatous. An injury to it may, in some cases, initiate malignancy. Apart from trauma, malignant changes may occur, apparently spontaneously, in a few weeks, though in some cases a papilloma may remain innocent for many months before any epitheliomatous lesion appears. Sometimes a papilloma may remain quiescent for a period of years. It is impossible to state the average time a wart may remain benign and free from malignant changes. Once it has started on its career as a carcinoma, however, the progress of the growth is much more rapid, and as the months pass the prospect of an effective cure is diminished. Ulceration of the epithelioma causes the discharge of a sanious fluid. When it is situated on the scrotum it spreads to the glands of the groin, and from there to internal structures. In other locations, *i.e.*, the arms and face, it appears to be slower in growth and is therefore more amenable to treatment.

### *Pathologic Characteristics*

*Pitch Papilloma:*

The pitch papilloma, sessile or pedunculated, is a peculiar form of cutaneous wart, marked by excessive keratinization. Apart from the latter feature it resembles the common wart, verruca vulgaris, in its histologic appearances. It is, like the latter, a specific form of epithelial overgrowth. Its structure exhibits a hyperplasia of the entire malpighian layer, with folds and projections into which extend thin strands of stroma. The form of the papilloma is chiefly determined by the local conditions surrounding the tumor. Outward growth of the hyperplastic cells is in the line of least mechanical resistance.

*Pitch Epithelioma:*

The sessile pitch papilloma, after its transformation from a benign into a malignant tumor, shows all the characteristics that are typical of a squamous-celled carcinoma.

The first histologic change which is observable is a downward instead of an upward growth of the hyperplastic epithelial cells. They invade the cutis vera, and at the beginning are of the flattened squamous type. Gradually some of them tend to become more flattened and undergo keratinization, and if concentrically arranged, form cell nests. These, if keratinization is complete, form the so-called epithelial pearls. In the younger parts of the invading growth the squamous cells tend to become more and more atypical; they are, for the most part, spheroidal, and the stroma is abundantly cellular, with imperfect fibrillae.

### Description of Seventy-Three Cases

The seventy-three men whose cases I am about to describe and analyze were examined by me in the capacity of certifying surgeon for Cardiff and district (under the Factories and Workshops Act) during the years 1922 to 1930, inclusive.

I have reason to believe, however, that this number does not by any means represent the total cases of pitch papillomas which occurred during this period of time. Many men were, I am informed, in the habit of going to their doctors and having their warts cauterized without giving any notification of

the fact to the company's representatives. These men of course lost no time from their work and had no need to claim compensation. I therefore did not see them.

*Age Incidence*

During nine years I saw only four cases of pitch papillomas occurring in men below the age of 30 years (Table 1). Two of these men were aged 29, one was 27, and one was 25. The youngest had worked eleven years as a pitch wheeler and had had two small sessile papillomas removed from his forehead a week before I saw him. The other three men showed pitch papillomas on the scalp, eyelid, and upper lip, respectively.

TABLE 1.—INCIDENCE OF PAPILLOMAS AND EPITHELIOMAS IN RELATION TO AGE

| AGE GROUP | NO. SHOWING PITCH PAPILLOMAS | NO. SHOWING EPITHELIOMAS |
|---|---|---|
| *yrs.* | | |
| 21–30 | 4 | 0 |
| 31–40 | 9 | 0 |
| 41–50 | 24 | 6 |
| 51–60 | 16 | 4 |
| 61–70 | 8 | 3 |
| 71–80 | 0 | 1 |
| Total..... | 61 | 14 |

The greatest number of papillomas was found in the age period from 41 to 50 years, with the next ten years, from 51 to 60, supplying the second largest number. I think one may rightly conclude from these figures that a patent fuel worker is most liable to develop a growth between the ages of 40 and 60 years.

Dr. Sladden (6) of Swansea, commenting on figures obtained as the result of an investigation of the Swansea patent fuel workers in 1920, which correspond very closely to those shown in Table 1, states that in his experience pitch warts become common at the age of 35; he found no epitheliomatous lesions in the 158 men he examined under the age of 50 years. Out of the seventy-three men whom I examined, fourteen showed definitely epitheliomatous lesions. The youngest of these were two men aged 42 years, one of whom developed an epithelioma on the scrotum, and the other on the upper lip. The eldest was a man of 76 who developed an epitheliomatous ulcer on the back of the left wrist. One man had a recurrence of an epithelioma on the left cheek two years after he had had it excised.

According to Prosser White (7), age *per se* is not considered to have much influence on the production of industrial cancer. In my opinion, however, it must be considered as a contributory cause in producing pitch papillomas in patent fuel workers, and as an especially important factor where the determination of malignancy is concerned.

One man I examined on eleven occasions, three men four times, three on three occasions, and eleven men twice. By far the greatest number of recurrent papillomas came in the decade from 41 to 50 years of age.

*Nature of Occupation*

All men employed in a patent fuel works are exposed to pitch dust and a certain proportion to fumes as well as to dust. These fumes arise from the heated fuel mixture and from the re-

cently prepared blocks of fuel before they have cooled down.

The men who handle the raw pitch and unload it from the vessels and trucks are known as pitch wheelers and pitch pilers. They are exposed to pitch dust alone. The millmen or pitch grinders, who grind the pitch before it is mixed with the small coal, are exposed to a like amount of pitch dust.

The men who heat the fuel mixture, and who have to decide when it is of a proper consistency to be passed on to the press, where it is stamped out into blocks, are known as heatermen or pugmen. The pressmen are those who look after the pressing machine, which shapes the heated fuel powder into oblong blocks. They are subjected to exposure to dust and to fumes coming from the heated blocks; their work is carried on more or less in the open air. The block regulator's work explains itself. He is the man who is appointed to see that the blocks keep stationary on the moving belt.

The rope runner is responsible for the haulage of the trolley loads on to the crane, or gantry, when the ships are being loaded. The men who stack the fuel blocks and who load up ships or wagons are known as fuel stowers or loaders.

The hostlers—two only are employed—look after the dozen or so horses which are kept to draw the fuel laden trolleys across the yards. These men, with the laborers and coal tippers, are constantly exposed to the dust which is always blowing about the factory premises.

The overmen are, in every case, men who have been employed in various capacities about the works for many years. They are therefore especially well qualified to act as foremen and overlookers of machinery, and to do odd jobs wherever their services may be required. Their age—in each case over 60 years—and length of service explain why they are so frequently affected.

Data derived from Table 2 show that the incidence of papillomatous growths is greatest among the heatermen, pitch wheelers, and fuel stowers. The heaterman is more exposed to intense heat and dust than any other class of fuel worker. He works in a very high temperature and in an atmosphere of dust and hot fumes which cannot be more than partially ameliorated by ventilation. Pitch wheelers and fuel stowers comprise more than half the number of men dealt with in this article. Apart from the fact that their number — ninety— is more than

TABLE 2.—INCIDENCE OF PAPILLOMAS IN RELATION TO OCCUPATION

| OCCUPATION | NO. OF PAPILLOMAS FOUND | NO. OF WORKMEN EMPLOYED |
|---|---|---|
| Heatermen or pugmen | 11 | 9 |
| Pitch wheelers | 23 | 54 |
| Fuel stowers and loaders | 20 | 36 |
| Laborers, coal tippers | 7 | 35 |
| Overmen (foremen) | 5 | 7 |
| Pitch grinders (millmen) | 3 | 18 |
| Block regulators | 1 | 4 |
| Pressmen | 1 | 6 |
| Rope runner | 1 | 3 |
| Hostler | 1 | 2 |
| Total | 73 | 174 |

a quarter of the total number of workmen employed at the factory, it is not difficult to understand why they are the class of workers so frequently affected with pitch lesions.

The pitch wheeler is continuously breaking up and handling the crude pitch inasmuch as his work consists in unloading it from the ships, breaking it up, and stacking it in the yard. While he breaks it up with his pick, small sharp pieces are frequently striking him on his exposed parts, causing tiny scratches and cuts. These minute traumas provide, in my opinion, an ideal site of entry for the pitch into the deeper layers of the skin and are the reason why, as Table 2 shows, the pitch wheeler is one of the class of workers most liable to develop a pitch papilloma.

The fuel loaders and stowers are most liable to these lesions inasmuch as they are working in a very hot atmosphere—the holds of the ship—handling blocks of fuel which have often not properly cooled down. These hot blocks give off fumes which some of the men complain are very irritating. The fumes are due to the use of superheated steam which helps to produce the proper mixture of the fuel before it is passed into a block. Theoretically the fuel blocks are supposed to remain in the yard twenty-four hours before they are ready to be shipped, but in practice, when there is a rush of work and many ships have to be filled in a short space of time, they are quite hot when they are being loaded into the ships' holds.

Heat, inasmuch as it causes perspiration—in certain individuals very profuse—has, in my opinion, much to do with the production of papillomas. Human sweat forms a very good solvent for the particles of pitch, and allows them to enter the surface of the skin much more easily than would otherwise be possible. Leitch drew attention to this fact in 1921 when he successfully provoked cancer in mice by painting them with an application of soot dissolved in a liquid similar to the sweat of human beings.

TABLE 3.—INCIDENCE OF GROWTHS IN RELATION TO LENGTH OF EXPOSURE TO PITCH

| LENGTH OF EXPOSURE | FIRST EXAMINATION | | SUBSEQUENT EXAMINATIONS | |
|---|---|---|---|---|
| | No. of Papillomas Found | No. of Epitheliomas Found | No. of Fresh Papillomas Found | No. of Fresh Epitheliomas Found |
| *yrs.* | | | | |
| 1–5 | 5 | 0 | 0 | 0 |
| 6–10 | 7 | 1 | 9[1] | 0 |
| 11–20 | 21 | 0 | 7 | 0 |
| 21–30 | 17 | 6 | 12 | 4 |
| 31–40 | 8 | 1 | 5 | 1 |
| 41–50 | 0 | 1 | 0 | 0 |
| Total... | 58 | 9 | 33 | 5 |

[1] Out of this total seven papillomas were found on seven separate occasions on one individual between November, 1925, and December, 1927.

Prosser White (3, p. 37) quotes Gardiner as saying that the oncoming of an occupational rash is hastened weeks by hyperhidrosis and months by seborrhea. There is no doubt in my own mind that profuse sweating is inimical to patent fuel workers, and is the reason why so many heatermen and fuel loaders develop pitch papillomas.

*Length of Exposure to Pitch*

Eighteen of the seventy-three men suffered from pitch papillomas on more than one occasion during the years 1922 to 1930. Of this total, eleven men were examined twice, three men three times, three men four times, and one man eleven times. On each occasion a new papilloma (and in only one case an epithelioma) was found (Table 3), so that altogether the series of seventy-three cases provided 109 examinations and, as will be shown later, 129 lesions.

The length of time during which the patent fuel worker is exposed to the irritant pitch is, I think, one of the most important factors in the etiology of both papillomas and epitheliomas. The greatest number of papillomas are found in men who have spent more than ten years of their working life in the industry. Including the recurrent papillomas (by recurrent I mean the growths that occurred *de novo* at varying intervals of time after I had seen the man with his first one), twenty-eight cases were seen in the decennial period from eleven to twenty years and twenty-nine in the following decade from twenty-one to thirty years. Five papillomas occurred in

TABLE 4.—NUMBER AND SITE OF LESIONS[1]

| SITE OF GROWTH | | | NO. IN 73 CASES ON FIRST EXAMINATION | | NO. IN 34 RECURRENCES | | TOTAL |
|---|---|---|---|---|---|---|---|
| | | | Papillomas | Epitheliomas | Papillomas | Epitheliomas | |
| Head and Neck Region | Scalp | | 2 | 0 | 1 | 0 | 3 |
| | Forehead | | 6 | 0 | 1 | 0 | 7 |
| | Orbits | | 4 | 1 | 3 | 0 | 8 |
| | Eyelids | | 7 | 0 | 6 | 0 | 13 |
| | Cheek | | 13 | 2 | 7 | 2 | 24 |
| | Lip | Upper | 7 | 0 | 4 | 0 | 11 |
| | | Lower | 3 | 0 | 1 | 0 | 4 |
| | Chin | | 2 | 0 | 0 | 0 | 2 |
| | Nose | | 8 | 0 | 9 | 0 | 17 |
| | Ear | | 8 | 0 | 1 | 2 | 11 |
| | Neck | Back | 1 | 1 | 3 | 0 | 5 |
| | | Side—behind and below ear | 0 | 0 | 0 | 0 | 0 |
| | | Front | 0 | 0 | 1 | 0 | 1 |
| | Forearm and wrist | | 4 | 1 | 1 | 0 | 6 |
| | Fingers | | 4 | 0 | 1 | 0 | 5 |
| | Scrotum | | 4 | 4 | 1 | 1 | 10 |
| | Penis | | 1 | 0 | 0 | 0 | 1 |
| | Leg | | 1 | 0 | 0 | 0 | 1 |
| Total | | | 75 | 9 | 40 | 5 | 129 |

[1] In seventeen of the papilloma cases the growths had been entirely removed by the man's own doctor and only a healing wound scar was visible.

men who had been employed for only five years. Teutschlaender (8), who carried out investigations into the patent fuel industry in Baden in 1929, records one case of papilloma in a man who had worked but seven years in the industry.

By far the largest number of epitheliomas arose after twenty years' exposure to pitch. The only recurrence of an epithelioma occurred after thirty years' work.

The number of men affected after forty years' service is less than the number affected among those with thirty years' work to their credit. A wider experience of the subject is necessary, however, before deducing whether the apparent freedom of this fraction of long service workers is due to more individual cleanliness, to less dusty conditions of work, or to some inherent immunity associated either with the texture of the skin and sweat ducts, or with some more deeply seated physiologic quality in the individual.

Table 4 includes 129 growths (papillomas and epitheliomas) occurring in the series of seventy-three persons with which this article is concerned. Of this number, forty-five growths (forty papillomas and five epitheliomas) appeared in men who had been examined on more than one occasion (one man I examined eleven times). Altogether the total number of papillomas found was 115 and of epitheliomas (as stated before) was fourteen.

*Papillomas:*

Patent fuel workers are naturally most liable to develop lesions in the parts of the body most exposed to pitch dust, and the figures in Table 4 prove this to be the case. The head and neck provide 106 growths, eight of which are epitheliomas and ninety-eight papillomas, more than two-thirds of the total number. It is interesting to note the distribution of the papillomas in this region.

The lip-cheek-eyelid area shows a preponderance of lesions—sixty in all: fifteen on the lips, twenty-four on the cheeks, and twenty-one on the eyelids and orbits. (This is noted by Kennaway (5), who finds that two-thirds of all the pitch cancers occur on the cheek, lips, eyelids, scrotum, and penis.) The nose is the next most prolific source of papillomas, with seventeen cases; the ear provides as many as eleven cases. I have not found many growths on the neck; if they occur they are always on the nape of the neck where the collar has rubbed. Friction, I think, has much to do with the large number of growths found in the head, ear, and neck region; apart from the number of times the men rub their faces with a towel, they must, many of them, contract habits of either rubbing their eyes, ears, or nose inadvertently, and in this way enhance the irritant properties of the pitch dust. The hands and forearms show eleven cases, one of which is an epithelioma. The scrotum, the common site for mule spinners' cancer, is seen to be the source of ten growths, and it is to be noted that half of them were epitheliomas. This, I think, is due to the fact that the men are shy and reluctant to report the presence of lesions in the genitals. Consequently, when they are seen by a doctor, the growth has passed the papillomatous stage and is a well-defined epithelioma.

I had only one case of a papilloma on the penis. It was situated on the

dorsum of the prepuce, and the inguinal glands were involved on both sides. I did not see the man until he had had his growth treated by his doctor, so that I am unable to give an opinion as to its size and character. From the account I received from the doctor, it was undoubtedly a papilloma of the sessile variety and due to pitch dust. The doctor had attempted to remove it with caustic application, with the result that it ulcerated and became infected; the inguinal glands were involved and a bubo in his right groin subsided after suitable incision and drainage. The papilloma was finally removed by excision.

*Epitheliomas:*

Five growths were situated on the scrotum, four on the cheek, and two on the ear. The growths on the ear occurred in the same man, the second epithelioma appearing close to the site of the first one after a two-year interval. I met with only one epithelioma on the neck, and only one on the forearm. The most remarkable case of the series was an epithelioma starting on the cornea of the left eye, which is described in detail later.

### *Nature of Lesions*

I have already stated that the seventy-three men provided altogether 129 lesions, and that of these, forty-five appeared in eighteen of the men who were examined on more than one occasion. It is now necessary to consider the nature of the lesions found.

| *Growths* | *Number* |
|---|---|
| Papillomas: | |
| 1. Sessile papillomas | 92 |
| 2. Sessile, with ulceration and secondary infection due to caustic applications | 4 |
| 3. Healing or healed wound scars, due to excision of papilloma. | 17 |
| 4. Pedunculated papilloma | 1 |
| 5. Papilloma not due to pitch | 1 |
| Epitheliomas | 14 |
| | 129 |

*Papillomas:*

*Sessile Papilloma.*—The majority of the cases I saw—ninety-two in all—showed growths of this type. They varied in size from about one-thirty-second of an inch to three-quarters of an inch in diameter:

| *Size of Papilloma* | *No. of Cases* |
|---|---|
| Less than $\frac{1}{4}$ inch in diameter | 8 |
| $\frac{1}{4}$ inch in diameter | 31 |
| Threepenny piece | 12 |
| Sixpenny piece | 5 |
| Shilling piece | 1 |
| No size recorded | 35 |
| | 92 |

Most of the men came to see me when they noticed that the wart was getting to be about the size of a moderately large pea—*viz.*, about a quarter of an inch in diameter. Unfortunately my records of the size of the growth in relation to the length of time it had been present are not quite complete for the whole series. Taking an average, however, from some forty cases I find that a sessile pitch papilloma generally measures about a quarter of an inch in diameter after four to six weeks' growth. At this stage the center is composed of a hard, protruding keratinized nodule. When the papilloma has grown larger and is about the size of a sixpenny piece (or half an inch in diameter), umbilication begins to show itself. The keratinized central punctum begins to disappear, leaving behind a crusty crater, as it were, in the

middle of the growth. This umbilication does not usually appear until the growth has been present from two to three months, although in one case I found it in a growth which, according to the man's story, had been present for only a month. This stage of umbilication is the immediate precursor to epitheliomatous ulceration. Umbilication showed well in four cases:

Case 1.—This man, aged 76 years, had had a pitch papilloma for about one month. When I saw him he showed an umbilicated papilloma on his left forearm, the size of a shilling piece. For some reason he neglected to get it removed at once, and when I had occasion to see him two weeks later I found that the umbilicated crusty center had liquefied, and that instead of a papilloma there was now a punched-out ulcer giving every appearance of an epithelioma. This diagnosis was subsequently confirmed histologically at the Cardiff Infirmary. I have included this case in the series of fourteen epitheliomatous lesions to be discussed later.

Case 2.—This patient, aged 45 years, showed a sessile, button-like growth of four weeks' duration on the molar region of the right cheek. It was a third of an inch in diameter and becoming hollow.

Case 3.—This patient, aged 45 years, had an umbilicated papilloma, the size of a shilling piece, of six to eight weeks' duration, on the right molar region of the face.

Case 4.—This man, aged 58, had an umbilicated papilloma half an inch in diameter just outside the outer canthus of the left eye, which was of ten weeks' duration.

In my experience a pitch papilloma takes at least two months to attain a diameter of half an inch. Generally it takes longer—from three to four months. When it has reached this size, it invariably begins to umbilicate and take on the other clinical characteristics which enable an observer to identify it without difficulty as an epitheliomatous formation.

*Sessile Papillomas with Ulceration and Secondary Infection Due to Use of Caustics.*—Four cases occurred where papillomas of the sessile type were unsuccessfully treated with repeated applications of caustics before the men presented themselves to me for examination. One man aged 38 years had had a pitch wart on his prepuce cauterized with silver nitrate. The growth became infected and he developed a bubo in his right groin and an adenitis in his left inguinal region which eventually resolved itself without an incision. When I first saw him he had a small circular healing area on the dorsum of the penis and a discharging abscess in the right inguinal region where the bubo had been lanced by his doctor. Another man with a scrotal papilloma said that he had had three or four applications of silver nitrate without any result, except much pain and soreness over the part.

The other two men had papillomas, with much redness and inflammation around them, situated on the angle of the mouth and the back of the hand respectively. In each case repeated applications of acetic acid or silver nitrate had caused some ulceration in and around the growth, with secondary infection of the tissues, and I was obliged to send them both to the Cardiff Royal Infirmary for further treatment. The lesions were eventually excised.

In my opinion strong caustics, such as silver nitrate, chromic and nitric acid, are inadvisable for the removal of papillomas at any stage of their growth. They destroy the tissues too quickly and cause them to suppurate.

*Healing or Healed Wound Scars Due to Treatment.*—Seventeen cases showed

healing or healed scars only, as the men had had treatment for their papillomas before coming to see me; twelve men had had their growths removed by excision and five by means of caustic applications.

*Pedunculated Papillomas.*—I have met with only one case where any physical discomfort or incapacity for work has arisen from this type of papilloma. As I have already explained, these little stalked projections generally drop off without causing the least inconvenience. The patient in question was a fuel worker 65 years of age, with a duration of employment in the industry of some thirty years. He told me that he had had a small wart on the edge of his right upper eyelid for two or three months before he stopped working. He was obliged to give up on account of intense pain and inflammation in the right eye. When I saw him he had a corneal ulcer and hypopyon, with a great deal of conjunctivitis. A tiny pit caused by the scar of the papilloma could be seen with a lens on inspection of the right upper eyelid—at about its middle. He said that his doctor had removed the little wart quite easily with a forceps on his first visit to the surgery.

*Papilloma Not Due to Pitch.*—One man (Case 22), aged 36 and with a duration of employment in the industry of nine years, came to me with a very small papilloma on his left shin. He was unable to tell me how long he had had it. It had no characteristics of a pitch papilloma, and appeared to me to be an example of a congenital papilloma of the sessile type; I was unable to get a histologic examination as the man refused to have the growth excised.

*Epitheliomas:*

*Scrotal Growths.*—Following is a description of the five cases observed:

Case 1.—J. V., aged 58, had an epithelioma the size of a shilling piece just to the left of the median raphe. He had scars of an operation in both inguinal regions and on the left side of the scrotum, where he had an epithelioma with metastasis in the glands in 1920. The length of exposure to pitch was twenty-nine years.

Case 2.—B. O., aged 42, had an epithelioma the size of a two-shilling piece on the left side of the scrotum, with stony hard glands in both groins. The length of exposure to pitch was eight years.

Case 3.—J. D., aged 63, had an operation scar on the median raphe of the scrotum. The left inguinal glands were stony hard and swollen, and suggested metastasis. The length of exposure to pitch was twenty-eight years.

Case 4.—T. D., aged 63, had an epitheliomatous ulcer 1 inch in diameter to the left of the median raphe of the scrotum. There were hard, stony glands in both groins. The length of exposure to pitch was twenty-two years.

Case 5.—P. O., aged 65, had an epithelioma the size of a sixpenny piece on the right side of the scrotum, over the anterior aspect of the right testicle. A few small glands were palpable in both groins. The length of exposure to pitch was from thirty to forty years, but the man had not worked in the patent fuel works for a year. This case affords a good example of the latent period which may elapse between exposure to pitch dust and the appearance of the lesion.

All the scrotal growths appeared on the anterior aspect of the scrotum; in every case the inguinal glands were involved. In other parts of the body the glands do not seem to be affected so quickly, for in only one of the remaining cases, an epithelioma of the face, have I a record of their involvement. In Case 1 the man had had an epithelioma on the same side of the

scrotum twelve months prior to my seeing him.

Case 5 is especially interesting as it affords a good example of the latent period which may elapse between the time a man was last exposed to pitch dust and the appearance of the lesion. In other words, it is not essential that the exposure to pitch should be continuous. The warts and epitheliomas may appear months or years after the man has stopped working.

This latent period has also been noted in mule spinners' cancer, where, as Henry (9) says, "the disease may declare itself long after the patient has retired from the industry." It has also been found in skin cancers due to soot, shale oil, arsenic, and X-rays.

*Growths in Head and Neck Region.*—Three cases presented well-defined epitheliomatous lesions on the cheek. One man had an epithelioma removed from just in front of the left ear in 1925, and then appeared before me again in 1927 with a second growth in almost identically the same place. It was, however, not a recurrence of the first epithelioma inasmuch as it arose just outside the scar tissue caused by excision of the first lesion.

Two epitheliomas arose on the helix of the ear. In one case I did not see the growth, as it had been excised in the Cardiff Royal Infirmary before I saw the man.

Another was situated on the side of the neck, a little below and posterior to the lobe of the left ear, with a pitch papilloma the size of a hazelnut just behind the helix of the left ear. The latter growth, so the man told me, started about two weeks after the epithelioma.

The only other epithelioma found in the head and neck region was an epithelioma of the cornea. This is the first example of a corneal epithelioma due to pitch that I have heard of in this country, and it is interesting to note a reference to tar carcinoma of the cornea in man, by von Berger (10). In a coal porter of 38 he found a nodule on the limbus of the cornea, together with iritis. The nodule was removed and found to be a prickle-celled carcinoma with horny pearls. A splinter of tar got into the eye and had lodged in the cornea, causing the tumor by chemical irritation.

*Epithelioma of Cornea.*—Because of its rarity and unusual features, I propose to describe a case:

> The patient, W. W. (whom I saw on Oct. 27, 1929), was 49 years of age and had worked in the industry for thirty-four years. He had had a pitch wart removed from his left cheek by caustics sixteen years previously, when working in the yard. He gave a history of having worked on the gantry for the last twenty-three years, and stated that on Feb. 4, 1926, something flew into his right eye and disabled him for sixteen days. He said that he had had trouble with his eye off and on ever since. He had been idle since June, 1929, when he started attending the Ophthalmic (outpatient) Department of the Cardiff Royal Infirmary. On July 1, the ophthalmic surgeon, Mr. Tudor Thomas, operated on his eye and told him he had taken away a piece of growth from the eye for examination. Six weeks later the whole of it was cut away.

When I examined the patient in October, 1929, all I could see was considerable conjunctivitis and evidence of operative interference in the lower part of the left cornea. I later got into touch with Mr. Tudor Thomas, who has kindly furnished me with the following description of the case:

The patient is a fuel worker, aged 52. There is history of fuel dust entering the right eye three and one-half years ago, followed immediately by inflammation of the eye, which is still present. I am informed that the fuel dust contained 6 per cent. of pitch.

When first seen by me in August, 1927, there were three separate grayish-white patches on the eye—one on the cornea, one on the inner limbus, and one on the bulbar conjunctiva. They were slightly raised and had the appearance of grayish-white keratinized material. There was some conjunctival injection. The patient said that these white patches had been present for several months. Two months later the conjunctival patch had disappeared and the other two patches had merged into one large patch, which extended from the inner side of the cornea horizontally outward below the pupil, but did not reach the lower margin of the cornea.

In August, 1929, further extension had taken place across the limbus from 4 to 6 o'clock, forming a somewhat triangular-shaped growth about 7 mm. in extent.

In September, 1929, the growth was dissected away from the corneal stroma and removed. A conjunctival flap was drawn over the raw areas. Three weeks later a white patch began to form at the limbus at 7 o'clock, and in the course of a further three weeks this had extended along the edge of the conjunctival flap to 3 o'clock on the corneal margin.

The white marginal growth was about 2 mm. broad. Vision in this eye was 6/36.

Microscopically, the growth showed great thickening of the epithelium with a thick stratum corneum and papilliform down growths of epithelial cells with leukocytic infiltration at the base. Cell nests could be seen, and numerous prickle cells. The condition did not appear to be one of xerosis. The patches were not frothy in appearance and were not easily removable. There was no condition of exposure of the eye such as would lead to the formation of epidermoid cornea, although there was primarily a definitely irritative condition.

It is well known that fuel dust and pitch containing materials cause much conjunctival irritation. Comparing the appearances in this case with those described in congenital epidermoid plaques of the cornea, our notes in the former, both microscopically and clinically, show a tendency to assume malignant characteristics that is absent in the latter.

The original appearance of three separate areas, of which one disappeared and the other two fused, does not quite correspond to what one expects to find in a malignant epithelioma. It seems probable that the original injury with fuel dust was an etiologic factor in the production of the growth. If this is so, one is tempted to compare the corneal condition in the case described above with those changes in the skin that are caused by pitch irritation. One of the changes so produced is a pitch wart. Pitch warts may be multiple, and are known to have a mildly malignant tendency, showing microscopically down growths of epithelial plugs, numerous cell nests, increase of stratum corneum, and basal leukocytic infiltration.

Bearing in mind the slight tendency that there is for corneal tumors to penetrate deeply, the microscopic appearances in this case show some similarities to those found in pitch warts. A pitch wart has mild malignant potentialities, and the recurrence in this case shows a similar tendency.

The growth did not disappear until the man had had two applications of radium. In February, 1930, I saw him with Mr. Tudor Thomas, and the growth was the size of a pinhead just at the limbus. By June, 1930, it had cleared up altogether, and all that could be seen was a small scar on the

cornea. The man is now back at work again.

*Cases of Multiple Lesions*

O'Donovan (11) notes the tendency to multiplicity of the skin lesions due to tar. Table 5 is comprised of multiple lesions found in sixteen out of the seventy-three men I examined. Two of these presented themselves twice

TABLE 5.—MULTIPLE LESIONS IN SIXTEEN CASES

| CASE | SITE OF LESION | NO. OF LESIONS |
|---|---|---|
| 1 | Scrotum and cheek | 3 |
| 2 | Scrotum | 3 |
| 3 | Thumb and middle finger | 2 |
| 4 | Cheek and upper lip | 2 [1] |
| | Nose, eyelid, and eye region | 3 |
| 5 | Nose and cheek | 2 |
| 6 | Forehead and upper lip | 2 [1] |
| | Eye region and side of neck | 3 |
| 7 | Nose and eyelid | 2 |
| 8 | Forearm and index finger | 2 |
| 9 | Ear and scrotum | 2 |
| 10 | Nose and upper lip | 2 |
| 11 | Forehead and upper lip | 2 |
| 12 | Neck (epithelioma) | 2 |
| 13 | Nasolabial sulcus | 2 |
| 14 | Eyelid and scrotum | 2 |
| 15 | Forearm | 2 |
| 16 | Forehead | 2 |

[1] On two different occasions.

with more than one papilloma. The greatest number of papillomas I have seen growing together is three, and as will be seen, I found this number in four men out of the sixteen. In one case they were situated on the scrotum, in two they occurred in the head and neck region, and in the other on the face and neck associated with an epithelioma on the scrotum. The rest of the men had two growths each, of which in two instances one of the lesions was an epithelioma. In eleven men the papillomas were found in the head and neck region and in two on the hands and forearm. The remaining three had one growth on the scrotum and the other in the head and neck region.

*Period of Delay*

In common with mule spinners' cancer and other occupational cancers caused by tar and its derivatives, petroleum oil, arsenic, and X-rays, pitch papillomas may occur at varying periods of time after exposure to pitch has ceased. It has been produced experimentally by the late Dr. Archibald Leitch, as stated previously.

In this series of seventy-three cases I have come across three examples of this latent period:

CASE 1.—L. M., aged 48 years, had a pitch papilloma on the side of the nose near the tip, about 2 mm. in size and of three weeks' duration. When the papilloma first appeared, he had not been working in a patent fuel works for three years.

CASE 2.—J. D., aged 76 years, had worked a week after being idle for two years. He told me he had had a wart on his left forearm about a month before he started work.

On examination I found a button-like growth, with ulceration beginning to appear in its center. On excision it proved to be an epithelioma.

CASE 3.—P. O., aged 65 years, had not worked with pitch for a year. I found an epitheliomatous ulcer the size of a sixpenny piece situated on the front of the scrotum. It had been present for three months. There were also three papillomas about an eighth of an inch in diameter situated on his face—two on the right cheek and one on the left.

The epithelioma was excised and the facial lesions removed by diathermy at the hospital.

These cases help to prove that pitch and other tar products are liable to produce what may be termed an unstable condition of the skin. That is to say, the epithelial cells are affected in such a way that in response to some unknown stimulus occurring months or years (as in these cases) after the original exposure to irritation from pitch, etc., has passed away, they suddenly develop carcinogenic properties.

These cases are also interesting from the medicolegal point of view. Occurring as they did more than twelve months after the men had stopped working they were, strictly speaking, not entitled to compensation from the employers under the Workmen's Compensation Act. This is, of course, manifestly unfair, as the men were undoubtedly suffering from an industrial disease.

Closer co-operation is needed between the state on the one hand and the medical and legal professions on the other, to insure that justice is done in cases such as these. However undesirable it may be for the state to acquire the right of interference between doctor and patient in his intimate professional relations, it must be conceded that here is just reason for relaxing a rule that should be inexorable in other respects.

### *Reaction to Sun and Wind*

Sixty-five out of the seventy-three men complained of suffering intense burning pain on exposure to sun and wind after the day's work; twenty-seven stated that the pain became worse after bathing. Only seven workers said that they felt perfectly comfortable at the end of the day. Out of the seventy-three cases only sixteen were of the blond type.

### Treatment

The various forms of treatment adopted in this series of cases were as follows:

| *Treatment Adopted* | *No. of Cases* |
|---|---|
| Carbon dioxide snow | 39 |
| Excision | 39 |
| Caustics | 17 |
| Diathermy | 13 |
| Radium | 1 |
| | 109 |

The greatest number of papillomas were removed by the application of carbon dioxide snow or by excision. Carbon dioxide snow, until a short while ago, was the routine treatment adopted at the Cardiff Royal Infirmary in the case of the smaller-sized papillomas—*i.e.*, about a quarter of an inch or less in diameter.

All the growths were completely removed and the men were able to go to work in a very short time—a week at the most. I have not heard of any recurrence of a growth or of malignancy being provoked in a papilloma following this mode of treatment. Although a carcinogenic agent, carbon dioxide snow does not appear to enhance the development of pitch papillomas. In this respect it is interesting to read of Berenblum's (12) experiments carried out in 1929. He first proved the carcinogenic properties of carbon dioxide snow by penciling an area of the skin on the back of mice for from six to fourteen months. At the end of this time he had provoked four tumors in a series of seventy mice, three of which were definitely malignant. In his second experiment he

took three series of forty mice. In one series he investigated the continued effect of freezing and tarring, and in the other two, of freezing alone and tarring alone. The series subjected to freezing only, showed one doubtful tumor. The results of the other two proved clearly that the development of tar tumors is not enhanced by the additional trauma of repeated freezing of the skin. On the contrary, freezing interfered with the rate of growth of the warts and hindered the tendency of the warts to become malignant, though it did not delay the induction of the warts.

In the case of the larger papillomas and epitheliomas, excision has been the mode of treatment adopted in practically every case, both by the man's doctor and also at the Cardiff Infirmary. In the case of the epithelioma of the cornea it proved unsuccessful and had to be supplemented with radium. In another case which I saw, the surgeon had allowed an insufficient margin of skin when removing an epithelioma on the cheek, and as a result the growth has recurred and will now necessitate treatment with radium. An important preliminary to the operation of excision in the case of pitch papillomas is previous cleansing of the growths with fomentations. Even with these precautions the incisions often suppurate. This is especially true of the scrotal warts which have become epitheliomatous and require treatment by complete excision with removal of the inguinal glands. Primary union of the skin incisions is the exception rather than the rule. All the men who were treated by repeated applications of caustics were in the hands of their doctors before I saw them. Strong caustics, such as silver nitrate, chromic and nitric acids, destroy the tissues too quickly and cause them to suppurate. In this way they may contribute to the recurrence of the wart.

The most recent form of treatment adopted at the skin clinic of the Cardiff Royal Infirmary has been the use of the diathermy knife. This has taken the place of carbon dioxide snow for the treatment of the smaller-size papillomas only. It has seemed satisfactory so far in thirteen cases. The ideal form of treatment, however, for these lesions appears to be that advocated and practised by Dr. W. J. O'Donovan at the London Hospital. The technic which he has kindly described to me is as follows:

> Platinum filtered glass seeds are used containing approximately 1.5 millicuries of radon. These are inserted under the growth through a fine stab; the radon undergoes degeneration; the capsule is expressed after five days and the growth shrinks with practically no local reaction.
>
> Thus the man is cured with very little pain and inconvenience to himself, and in the case of the large growths and epitheliomas, in a considerably shorter time than if he had had to have his growth excised

### *Present State of Cases*

Forty-seven out of the seventy-three men are quite well and working at their old jobs. Two are working in other industries: one could not get a job in the works, and he has taken up market gardening instead; the other (A.B.) received a lump sum settlement instead of weekly compensation for the epithelioma on the helix of the left ear, and has now started a small shop. Eighteen men are idle on account of trade depression. Two are incapaci-

tated through illness: one has heart disease, and the other suffers from the effects of a gastric ulcer which perforated in July, 1930. One man, aged

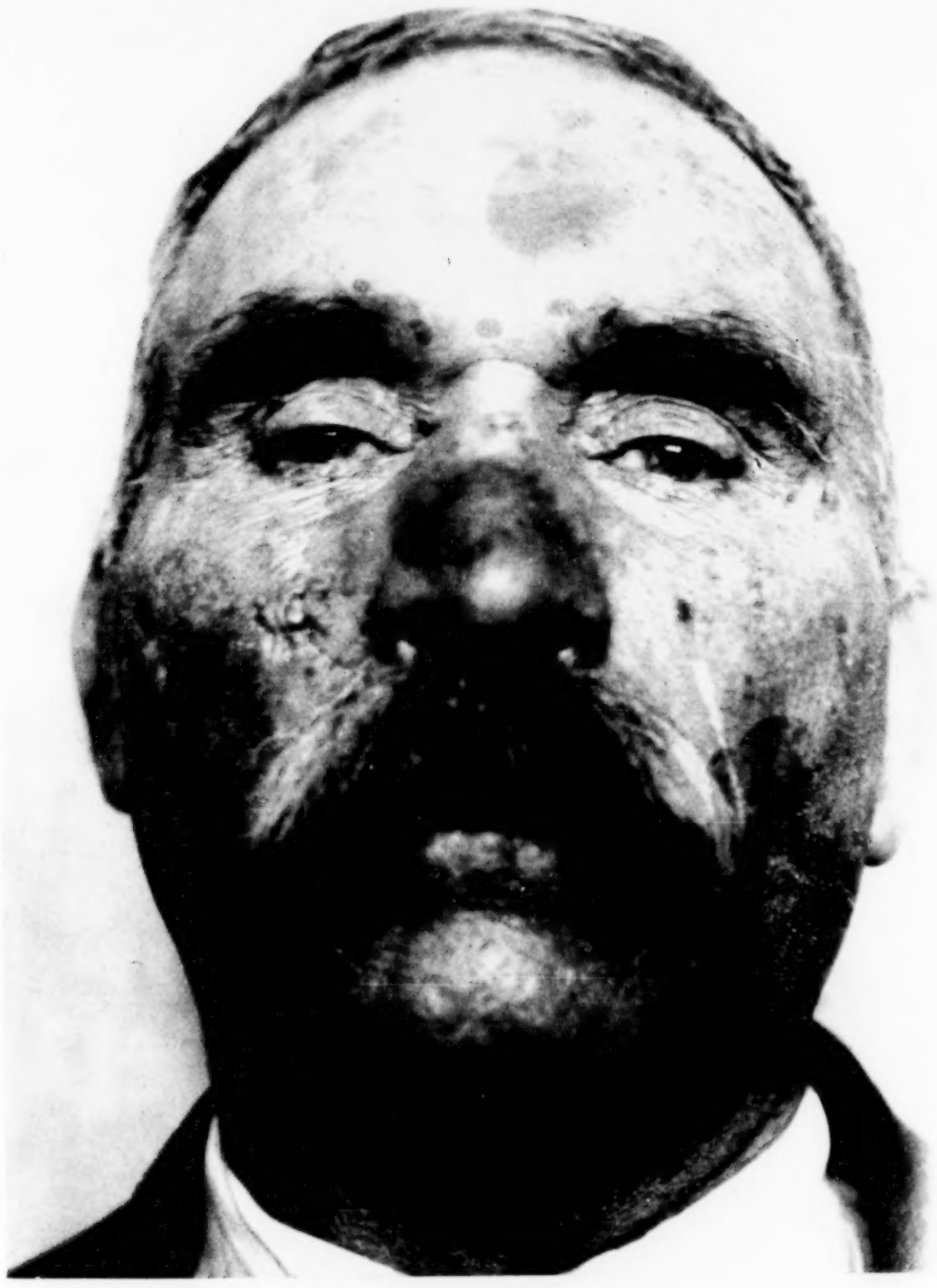

FIG. 3.—J. K., coal tipper, aged 65.

Showing a pitch epithelioma recurring a few weeks after excision had been performed. The growth is now being treated with radium.

60 years, died of cardiac disease. Only three are now incapacited by reason of a recurrence of pitch epitheliomas:

CASE 1.—J. K., came to see me on March 20, 1931, with an umbilicated pitch papilloma situated on about the middle of his right cheek. It was approximately a quarter of an inch in diameter, and about to ulcerate. I sent him to the Cardiff Royal Infirmary, and the growth was excised on March 23. On April 4, he came to see me again as the "wart was coming back." I found that the growth had recurred, as excision had evidently been carried out without allowing a wide enough margin. Its appearance now was that of a typical

epithelioma (see Fig. 3). I have sent him to the hospital again, and have arranged for him to have radium treatment.

Case 2.—E. J. L. came to see me on April 2, with a typical papilloma about an eighth of an inch in diameter situated approximately half an inch below the middle of the lower lip (see Fig. 4). It was excised on April 18.

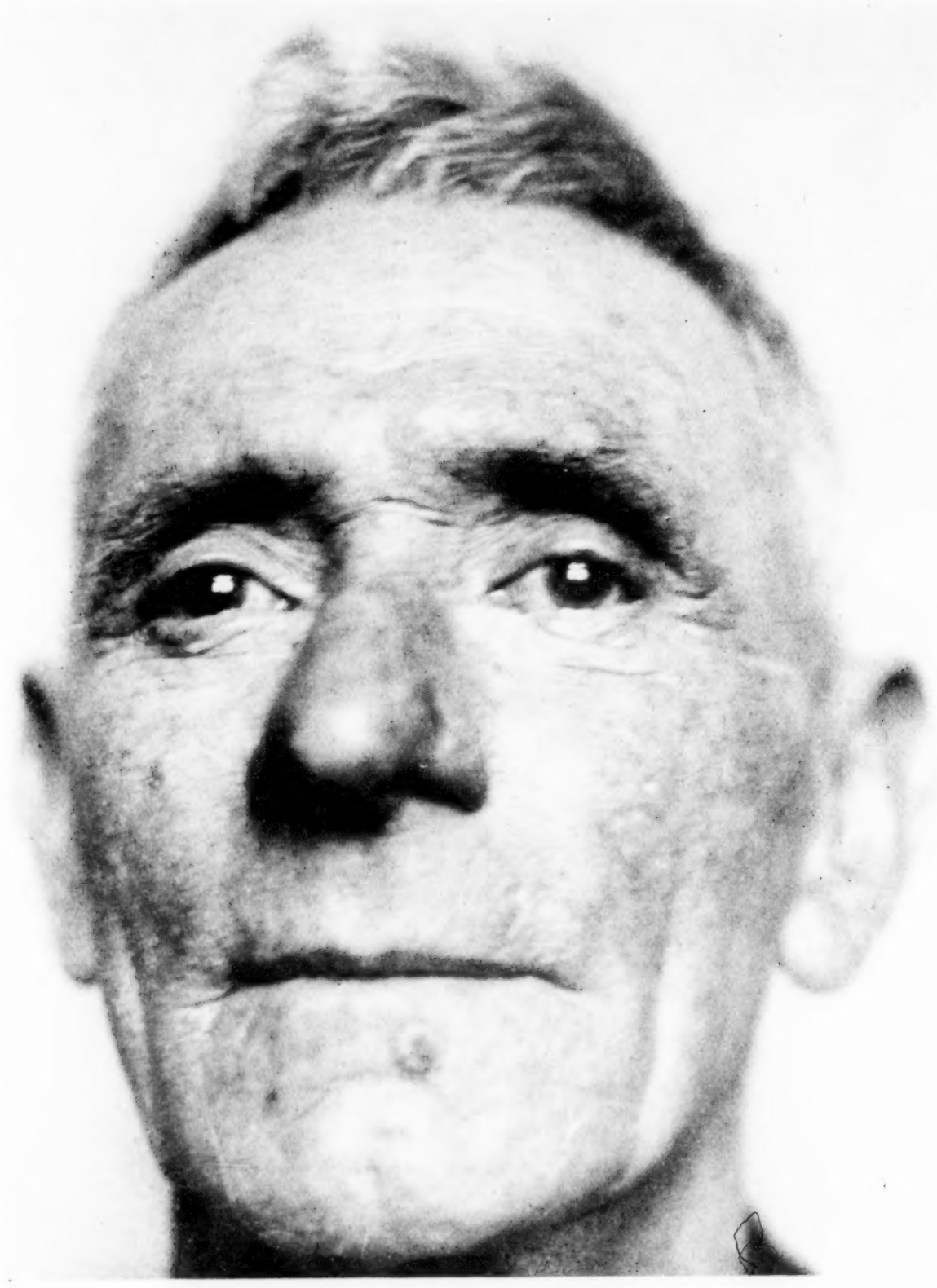

Fig. 4.—E. J. L., overman, aged 67.

A good example of a button-like pitch papilloma of three to four weeks' duration. The central keratinoid spur is well shown.

Case 3.—J. B., when reexamined on April 13, showed me a typical epithelioma-tous ulcer about the size of a two-shilling piece. It was situated on his left forearm, and had been there for about two months. He said that it had been a wart until a week previously, when he had accidentally knocked the top off it. I sent him to the Cardiff Royal Infirmary, where he had it excised.

From Table 6 it will be seen that in nine years, out of a total of eighty

men only thirty received compensation —twenty-one with pitch papillomas

TABLE 6.—CASES OF PAPILLOMA AND EPITHELIOMA FOR WHICH COMPENSATION WAS PAID

| YEAR | NO. OF CASES REPORTED | NO. OF CASES PAID COMPENSATION | DAYS LOST[1] |
|---|---|---|---|
| 1922 | 5 | 3 | 60 |
| 1923 | 6 | 4 | 151 |
| 1924 | 5 | 4 | 60 |
| 1925 | 8 | 1 | 114 |
| 1926 | 9 | 1 | 9 |
| 1927 | 12 | 7 | 195 |
| 1928 | 10 | 2 | 25 |
| 1929 | 10 | 4 | 505 |
| 1930 | 15 | 4 | 100 |
| Total . . . | 80 | 30 | 1,219 |

[1] By men receiving compensation.

TABLE 7.—TIME LOST BY MEN WITH EPITHELIOMAS

| CASE | AGE | SITE OF GROWTH | DAYS LOST |
|---|---|---|---|
| | *yrs.* | | |
| 1 | 60 | Scrotum | 42 |
| 2 | 61 | Face | 61 |
| 3[1] | 38 | Penis | 114 |
| 4 | 52 | Scrotum | 83 |
| 5 | 64 | Right ear | 43 |
| 6 | 55 | Left ear | 41 |
| 7 | 55 | Scrotum | 293 |
| 8 | 40 | Eye (cornea) | 170 |
| 9 | 76 | Forearm | 54 |
| Total . . . | .. | ..... | 901 |

[1] Case 3 was probably not an epithelioma but an infected pitch papilloma with involvement of the inguinal glands.

and nine with pitch epitheliomas. The total amount of time lost by these thirty men amounted to 1,219 days, of which 901 were lost by the men who suffered from epitheliomas (see Table 7). This leaves 318 days as the time lost by the twenty-one men who had papillomas.

In short, the average time necessary to get rid of a pitch papilloma which was of sufficient size to cause the men to stop work and seek treatment, was fifteen days per man.

## General Conclusions

### *Nature of Pitch Papillomas and Epitheliomas*

1. An epithelioma which arises out of a papilloma is the greatest industrial hazard to which the patent fuel worker is subjected. He suffers great discomfort from skin irritation and eye inflammation, but these are trifling when compared with cancer.

2. Every sessile papilloma with a smooth, raised rounded edge and keratinized puncture (in short a sessile pitch papilloma) is, in my opinion, a potential epithelioma. The pedunculated papilloma, on the other hand, has yet to show malignant tendencies, and apart from very rarely indeed causing trouble in the eye, appears to be quite harmless.

3. The length of time taken by a sessile papilloma to develop into a growth which may be clinically recognized as an epithelioma is variable; it may be a matter of weeks, months, or even years.

4. Papillomas are most likely to occur when a man is between 40 and 60 years of age.

5. Pitch wheelers, fuel stowers, and heatermen are the classes of workmen most liable to develop lesions.

6. The greatest number of papillo-

mas is found in men who have worked in the industry more than ten years. It should be noted, however, that I saw five men with papillomas who had been employed for only five years or less.

7. Papillomas due to pitch are most commonly situated on the head and neck region, the scrotum, and the forearm and hands. A papilloma found on any other part of the body is not, in my opinion, a true pitch wart. The presence of an epithelioma on the cornea, due to pitch, is, I think, of especial interest.

8. Sixteen cases occurred of multiple pitch papillomas—mostly in the head and neck region. Multiplicity of the lesions is a characteristic of papillomas produced by pitch.

9. Pitch papillomas may develop months, or it may be years, after exposure to the pitch irritant has passed.

10. Pitch epithelioma is, relatively speaking, a benign form of cancer with a very low mortality. None of the seventy-three men have died from its effects, and only three are disabled at the present time because of it. These men have been seen by me recently, each one having developed a fresh epitheliomatous lesion.

11. The average time lost by a man who is disabled by pitch papilloma which has not definitely become epitheliomatous but is large enough to need excision, is about fifteen days per man.

### *Methods of Treatment*

The problem of how to eliminate the dangers of papilloma and epithelioma is a difficult one. Until the cancer producing properties of pitch are discovered and removed, or some non-carcinogenic substance is substituted for it in the patent fuel industry (as in the United States), attention must be directed in other directions for the protection of the patent fuel worker. The measures to be taken may, I think, be classed under two headings: preventive; and curative.

*Preventive.*—I should suggest periodic medical examination of the men, preferably at the works, during working hours, as it has been found by experience that they do not present themselves for examination if it is made to take place in their leisure hours.

The frequency of the examination has next to be considered. It should, I think, take place every three months; in my experience any longer interval of time may allow the disease to assume proportions which diminish the chances of cure. The examinations, if possible, should be voluntary. If, however, after a period of twelve months it is found that the men do not attend regularly, I think they should be made compulsory.

In this way papillomas and epitheliomas would be recognized in their early stages, and their removal by operation rendered an easy matter. A certain cure would then be assured in all cases.

In addition, during these examinations, it would be possible to educate the men in the matter of personal cleanliness and the importance of reporting at once any suspicious lesions.

*Curative.*—In the case of the smaller-sized growths—quarter inch or less in diameter—carbon dioxide snow and diathermy have both given good results.

In the case of epitheliomas and large papillomas on the verge of malignancy,

excision has proved successful in most cases, but there is, nevertheless, a possible chance of recurrence in spite of the surgeon's exercising every care.

Radium, in the form of radon seeds, appears to be the best treatment so far devised for all kinds of pitch papillomas.

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GEWERBEKRANKHEITEN. Klinische Grundlagen der 22 meldepflichtigen Berufskrankheiten. By Dr. med. *Ernst W. Baader*, Dozent für Berufskrankheiten an der Universität Berlin, Chefarzt der Abteilung für Gewerbekrankheiten des Kaiserin Auguste-Viktoria-Krankenhauses in Berlin. Paper. Pp. 144 with illustrations. Berlin: Urban & Schwarzenberg, 1931.

This is a brief, clear, and up-to-date treatise on the chief diseases of occupation, including not only intoxications but silicosis, caisson disease, miners' ankylostomiasis, glass blowers' cataract, the carcinoma of aniline workers and of the cobalt arsenide miners of Schneeberg, and lesions from radiation—in short, the twenty-two occupational diseases which are reportable in Germany. The material is gathered largely from German sources, as is to be expected, but the British literature is fairly well covered as is also the Russian, and Swiss, Italian, and American articles are mentioned sometimes; the French only seem to be left out, which fact is especially conspicuous in the discussion of lead meningitis, for the credit for describing it is given exclusively to two Americans, Aub and Weller, with no mention of the voluminous earlier French work.

Lead and silica are the two substances dealt with most fully. On the various controversial questions in the first field Baader holds: (*a*) that a relative lymphocytosis is almost always present in lead poisoning except during an attack of colic when there may be a lymphopenia, followed, during convalescence, by a lymphocytosis; (*b*) that ulcer of the gastro-intestinal tract in lead poisoning has its origin partly in injury to the vessel walls, and partly in the repeated attacks of muscular spasm; (*c*) that a sclerotic kidney, anatomically the same as that of a late stage of glomerulonephritis, may be caused by plumbism, if the exposure has lasted from twenty to thirty years, and it is referable to repeated spasmodic contractions of the kidney vessels, resulting in arteriosclerosis; (*d*) that it is probable that many cases of so-called lead encephalopathy should be classed as lead meningitis; (*e*) that "lead neurasthenia" has nothing to do with lead as such; (*f*) that there is a true lead gout. Aub's method of treatment is recommended, though without giving him credit.

Baader warns the physician not to think that the late evidences of plumbism, such as sclerotic kidney, gout, palsy, encephalopathy, are to be rejected as evidence of lead intoxication because of the absence of early symptoms, stippled red cells, hematoporphyrinuria, and the lead line. The history of exposure to lead and of former attacks of acute poisoning is far more important. In looking for lead excretion, the stools are more important than the urine. The same is true of mercury.

Baader believes that there is a chronic form of hydrogen sulphide poisoning, characterized by a sense of pressure in the head, fatigue, vomiting, increasing weakness, emaciation

digestive disturbances, and an increased susceptibility to various infections, such as pneumonia, meningitis, also an inclination to chills and fever. Defects of intelligence, even dementia, may be a late manifestation. This form is far more common than the acute. He quotes Floret as saying that a grayish coating on the teeth is specific for poisoning by this gas.

Baader also accepts chronic carbon monoxide poisoning as a clinical entity and emphasizes the value of Löwy's symptom, a central labyrinthine overexcitability, evidenced by dizziness on rising in the morning and on looking up to the ceiling. He thinks that this form of poisoning shows that carbon monoxide has a direct toxic action and does not act only by oxygen deprivation.

It is plain that carbon disulphide, largely abandoned in American rubber manufacture, still holds its place in the industry in Germany and gives rise to much poisoning. It is also used to degrease wool and leather. He quotes Zangger to the effect that 0.15 mg. per liter of air is enough to bring about poisoning if exposure lasts a month.

With regard to silico-tuberculosis, Baader accepts the British and American view, quoting Watkins-Pitchford, Mavrogordato, and Gardner, but he discusses the theory of Lubarsch, Tenderloo, and others, who hold that the effect of silicosis is to prevent or hinder the development of pulmonary tuberculosis. He himself has seen silicosis in negroes of German Southwest Africa, caused by breathing desert sand, and also in an elderly Boer carter who for years drove an oxcart over sandy roads.

For those who read German easily, this short treatise might serve as a handy reference book.—*Alice Hamilton.*

THE PRACTICE OF ABSORPTION SPECTROPHOTOMETRY WITH HILGER INSTRUMENTS. A Guide to the Technique of Absorption Measurement in the Visible, Ultra-violet, and Infra-red Regions of the Spectrum. By *F. Twyman*, F.Inst.P., F.R.S., with the Collaboration of the Staff and Advisers of Adam Hilger, Ltd. Cloth. Pp. 80 with illustrations. London: Adam Hilger, Ltd., 1932.

RECENT APPLICATIONS OF ABSORPTION SPECTROPHOTOMETRY. A Bibliography Selected and Compiled by the Advisers and Staff of Adam Hilger, Ltd. Paper. Pp. 44. London: Adam Hilger, Ltd., 1932.

To those who are familiar with Twyman's "Practice of Spectrum Analysis with Hilger Instruments," which has run through five editions, this new book will be especially welcome. In the present handbook the author presents in easily understandable language the modern physical concepts underlying the phenomena of absorption spectrophotometry and the technic of measurement. The information that one has hitherto acquired by a process of slow accretion from the scattered literature of the subject is presented in this manual in logical sequence and compendious form.

The eight chapters discuss in turn: The Nature and Laws of Absorption; The Apparatus and Technique of Absorption Spectrography in the Ultra-Violet; The Apparatus and Technique of Absorption Spectrophotometry in the Visible Spectrum; The Apparatus and Technique of Absorption Spectrophotometry in the Infra-Red; The Application of Photoelectric Methods to Absorption Spectrophotometry; Chemical Applications of Absorption Spectrophotometry; Bi-

ological Applications of Absorption Spectrophotometry including its Application to the Study of Vitamin D and Allied Substances; The Application of Absorption Spectrophotometry to the Detection and Investigation of Poisons and to the Control of Purity of Foodstuffs. Two sections are appended dealing with Applications of Emission Spectra to Problems Likely to Interest Those Practising Absorption Spectrophotometry; and The Raman Effect and Some of its Applications.

The companion volume, "Recent Applications of Absorption Spectrophotometry," is a complete bibliography of the recent literature on the subject to January, 1932, with summaries and comments.

To investigators in public health chemistry those aspects of absorption spectrophotometry dealing with the detection and investigation of poisons and the control of purity in foodstuffs will be of particular interest.—*Lawrence T. Fairhall.*

PHYSICAL CHEMISTRY. An Elementary Text, Primarily for Biological and Premedical Students. By *Louis J. Gillespie*, Ph.D., Professor of Physicochemical Research, Massachusetts Institute of Technology; Formerly Fellow, Rockefeller Institute for Medical Research; then Biochemist, United States Department of Agriculture. Cloth. Pp. ix, 287 with index. First edition. New York and London: McGraw-Hill Book Co., Inc., 1931.

A knowledge of physical chemistry is of particular importance in certain fields of biology. Its lack is often keenly experienced and frequently not met with sympathy by the more formal treatises on physical chemistry. It is true that it has been met to some extent by the older treatises of Philip and of Findlay, but the present book goes further than these. It not only is an introduction for the biologist newly approaching the subject, but offers much material for those trained in an earlier school who wish to interpret their work in terms of present day conceptions. Whether one is interested merely in the proper choice of indicator to use with a given base or acid, or in some biologic application of the Donnan equilibrium, in the correlation of biologic phenomena with oxidation potentials, or in the relation of membrane permeability to the comparative toxicity of various chemical substances, one finds a discussion at once vital and interesting. Within twenty-six chapters the author has given the essentials of physical chemistry with a directness of discussion and an avoidance of abstract form that the biologist will find as useful as it is refreshing.—*Lawrence T. Fairhall.*

THE CAUSES OF ACCIDENTS. Three Lectures on Recent Research into the Causes of Accidents Given at the Royal Society of Arts under the Heath Clark Bequest to the National Institute of Industrial Psychology. By *Eric Farmer*, M.A., Investigator to the Medical Research Council's Industrial Health Research Board. Cloth. Pp. vii, 88 with index. New York and London: Isaac Pitman & Sons, Ltd., 1932.

This book presents in full the three lectures of which a synopsis was published in the March, 1932, issue of THIS JOURNAL (Article Section, p. 84). The topics discussed are: general factors affecting accident causation; individual susceptibility to accidents; the human factor in accident causation; and practical application of our knowledge of factors affecting accident causation. A useful bibliography of forty-four references is appended.—*Marion C. Shorley.*